Bridging two worlds? The troubled transfer of new environmental knowledge from science to consulting engineers

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Abstract

Today, there is a widespread political optimism regarding the role of scientific knowledge as a driving force for innovation and economic growth. Could this lead us to overestimate science's ability to provide innovations central to solve the challenges facing our society? This paper is a study of the appropriation of science in knowledge intensive services: specifically about how consulting engineers engage with new environmental knowledge. First, I investigate research communities' efforts with respect to transfer of new environmental knowledge to the consulting engineering industry. Second, I analyze consulting engineers' accounts of acquisition and use of scientific and other forms of new knowledge relevant to deal with environmental issues. The paper engages with the optimistic view by employing three theoretical perspectives, representing greater caution and highlighting different aspects of knowledge transfer and acquisition: Mode 2 theory, Latourian sociology of innovation and two-community theory. The ensuing empirical analysis challenges the optimistic views with regard to the role of new scientific knowledge for innovation; transfer efforts are limited and slow. Instead, the importance of indirect roads of transfer of scientific knowledge is emphasized, such as newly educated candidates and the development of regulations and codes. Another main finding is that consulting engineers' acquisition of new knowledge was guided mainly by pragmatic demand, generated through problem-solving in the context of application.

Science for innovation: the political optimism

Increasingly, science is expected to contribute to innovation and thus to economic growth but also sustainability. For such purposes, scientific knowledge is expected to move from universities, institutes and laboratories to industry. The focus of this paper is on the sociology of knowledge acquisition and dissemination with respect to environmental innovations in a knowledge-intensive industry – consulting engineers. Even if there is a large body of research studying innovation in general (e.g., Lundvall, 1992; Freeman and Soete, 1997; Fagerberg et al., 2005), the understanding of knowledge transfer in the context of innovation and problem-solving in knowledge-intensive companies needs to be further developed. In particular, this paper asks how and to what extent new scientific knowledge is made available to and acquired by an industry like consulting engineers? I approach these issues by studying how university engineering professors and research scientists account for their efforts to transfer relevant scientific knowledge as well as analyzing how consulting engineers say they appropriate new environmental knowledge from scientific institutions.

Policy-making communities seem confident in the ability of science to produce innovation. The recent European Union policy document *Europe 2020* is a prominent example.[1] Here, research and development (R&D) is granted a key role in strengthening the overall economy of the European Union. The vision involves "developing an economy based on knowledge and innovation" (p. 3). Implied in such views is a perception of scientific knowledge as intellectual property, produced, accumulated and traded like other services in the 'Knowledge Society' (Nowotny et al., 2003:185). Such beliefs express considerable optimism with respect to the transferability of scientific knowledge.

[1] Europe 2020 – A European strategy for smart, sustainable and inclusive growth. http://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%202020%20-%20EN%20version.pdf (downloaded 2011-02-25).

Typically, *Europe 2020* also expresses the need to align research priorities more closely with political goals. In the document, the Commission urges member countries to "re-focus R&D and innovation policy on the challenges facing our society, such as climate change, energy and resource efficiency, health and demographic change" (p. 10). Such aims make consulting engineers a particularly relevant group to study. Their work potentially has important and wide-ranging effects on the environment through for example physical planning or construction of buildings. Innovation in this context may mean radical as well as incremental changes in the content of the services offered, including making use of new scientific knowledge in project-based problem-solving. However, it should be emphasized that many consulting engineering companies rely a lot on re-use of previously developed solutions and thus may not find it important to innovate (Hojem and Lagesen, 2011; Amdahl and Sørensen, 2008).

To target the challenges of sustainability, *Europe 2020* commits to developing "a strategic research agenda (…) to improve framework conditions for business to innovate", and "promote knowledge partnerships and strengthen links between education, business, research and innovation" (p. 10-11). The expectation is that by improving framework conditions and strengthening the links between scientific knowledge producers and users, including higher education, increased and targeted innovation will take place. Is this optimism sound? Is new science-based environmental knowledge made use of by such actors as consulting engineers and how?

Science for innovation: Sobering perspectives

The traditional public image of scientific knowledge has been that of an 'intellectual bank account' that society may draw upon to fulfill its needs (Brooks, 1994). This image of science in innovation processes is also found in popular but simplistic models of knowledge transfer from scientific institutions to practice. The most traditional approach, 'the trickle-down view', holds that relevant scientific knowledge will reach practitioners without additional efforts required because science itself is an effective agent of knowledge transfer and innovation. The successor, the linear innovation model, assumes basic research to form the base of applied research, development work, innovation and implementation. However, unlike the trickle-down approach, this model acknowledges that scientific knowledge needs to be explicitly transferred to its users. Nevertheless, critics have for a long time argued that both models suffer from serious shortcomings (Kline and Rosenberg, 1986; Latour, 1987, 1998; van Kerkhoff and Lebel, 2006).

The critics claim that actors, knowledge components and processes of transfer are much more ambiguous, complex and dynamic than previously assumed (cf. Woolgar, 1994). However, there is no commonly accepted theory to replace the two traditional models but rather a broad range of alternatives (Sørensen, 2010). For the purpose of this paper, Jensen et al. (2007) usefully explore the tension between two ideal type modes of learning and innovation: One is based on production and use of codified scientific and technical knowledge, while the other is an experience based mode of learning. Although both modes play a role in most sectors, “there remains a bias among scholars and policy makers to consider innovation processes largely as aspects connected to formal processes of R&D, especially in the science based industries” (Jensen et al. 2007:681).

In addition to the distinction between codified and tacit knowledge, Asheim and Coenen (2005) argue that companies’ innovation processes are strongly shaped by their specific knowledge base. For consulting engineering, this is mainly a synthetic knowledge base, “where innovation takes place mainly through the application of existing knowledge or through new combinations of knowledge. Often this occurs in response to the need to solve specific problems coming up in the interaction with clients and suppliers” (2005:1176). This implies that scientific knowledge may play a limited role in the consulting engineering industry. However, know-how, craft and practical skill required in such industries are often provided by engineering scientists and universities and colleges that educate engineers. Thus, scientific knowledge may still be important but in a different way.

In this paper, I have chosen three approaches to the science for innovation issue in the solving of e.g. environmental problems. These three approaches have been selected because they highlight different aspects of the issue. First, the Mode 2 approach which emphasizes the importance of the context of application to the use of science. Second, a sociology of innovation alternative to the above-mentioned linear model, which accentuates the role of practice. Third, the so-called two-community theory developed in studies of use of social science in policy-making, which focuses particularly on cultural differences. Taken together, the three approaches represent greater caution in assuming that new scientific knowledge leads to innovation while illuminating different aspects of the dynamics of scientific knowledge transfer and acquisition.

The Mode 2 approach

According to Gibbons et al. (1994) the production of scientific knowledge has increased and moved beyond universities and research institutes through a more complex relationship to scientific disciplines and professions. This is claimed to have resulted in a marked growth in what they call transdisciplinary efforts, the activities that interdisciplinary teams of specialists engage in to perform ‘problem-solving in the context of application’ (Gibbons et al., 1994; Nowotny et al., 2003). Thus, new knowledge is either produced locally or acquired on the basis of need. What does such a model entail for consulting engineers, assuming that Mode 2 is a relevant description of their knowledge intensive work?

Consulting engineers offer so-called knowledge-intensive services (Filiatrault and Lapierre, 1997; Koch 2004; Hojem and Lagesen, 2011). However, the practice of consulting engineers is more problem-driven than actually knowledge-driven (Koch, 2004; Alam, 2003).

While it is not scientific knowledge production, the work of consulting engineers appears to fit the Mode 2 bill fairly well, with widespread transdisciplinarity and problem-solving in the context of application. However, according to Koch (2004), project learning and reflection is limited by the economy of the individual project. This limitation, the ‘tyranny of projects’ (Koch, 2004:296), results from expectations that each project shall be profitable.

The Mode 2 approach suggests that consulting engineers primarily rely on knowledge and experience already available in the company or developed through project work. Thus, we should anticipate environmentally related innovations in consulting engineering companies to have a distinctly local character. New scientific knowledge should be expected to be acquired by consulting engineers only if demanded through their problem-solving work, limited by ‘the tyranny of the projects’ (Koch, 2004). Thus, the Mode 2 approach provides modest expectations with respect to the amount of transfer of new scientific knowledge.

A sociology of innovation

There are various strands of sociology of innovation, but a common feature is a focus on innovation as a set of practices performed in organizational settings (Sørensen, 2010; see also Latour, 1987). Practice approaches also invite critique of the traditional linear model as misleading, joining historians Kline and Rosenberg in observing that this model “distorts the reality of innovation in several ways” (1986:286). Above all, science is seldom the singular driving force behind innovation.

Kline and Rosenberg (1986) proposed a ‘chain-link’ model that compared to the linear model provides a more detailed analysis of the reciprocal dependence between science and technology as well as producers and users of innovative products. In particular, they emphasize the dynamic coupling between technological forces and market dynamics. However, the chain-link model only nuances the linear view (Woolgar, 1994). Also, it fails to "acknowledge the organizational dimension and the wider institutional setting (…) in which distinct forms of learning take place" (Caraca et al., 2009:864).

A practice-oriented Latourian sociology of innovation is above all concerned with innovative actions of learning, combining and interpreting knowledge (Latour, 1987, 1998; Sørensen, 2010). In this sense, new scientific knowledge should be expected to be translated rather than just being transferred. Translation involves acts of mobilizing and creating interest in a given piece of scientific knowledge (including new technology) among potential users by making it attractive for them to embed it in local activities. Also, from a Latourian sociology of innovation perspective it seems pertinent to focus on knowledge practices related to the way consulting engineers manage environmental challenges, in addition to analyzing accounts of the role of new environmental knowledge in innovation or problem-solving efforts. Thus, compared to Mode 2 expectations about transdisciplinary learning and acquisition of new scientific knowledge based on needs emerging from problem-solving, Latourian sociology of innovation perspective invites a different focus. First, it makes us anticipate that professors and scientists will engage in translation work to persuade consulting engineers to use new scientific environmentally relevant knowledge (Latour, 1987, 1998). Second, consulting engineers should also be expected to do translation, primarily with respect to making their customers ask for more environmentally friendly solutions (Hojem and Lagesen, 2011).

Two worlds?

Studies of the use of scientific knowledge in policy-making, which is a kind of knowledge-intensive work, could also be used to analyze the challenges of knowledge transfer to a knowledge-intensive industry like consulting engineers. In general, findings from such research paint a fairly pessimistic picture. In a classical study of non-use, Caplan (1977) found three explanations. The first faults the behavior of scientists, while the second see policymakers as operating under conditions that limit their use of scientific knowledge. The third position – so-called two-community theory – argues that scientific and user communities communicate badly (Caplan, 1977). As Brooks (1994: 479) points out, “science, technology, and innovation each represent a successfully larger universe of activities which are highly interdependent, yet nevertheless distinct from each other”.

Such arguments suggest that cultural differences make the communication between scientists and consulting engineers difficult. Instead of being a result of a “slow flow” of relevant knowledge, Caplan (1977) found that the difficulties in knowledge transfer to policy-makers “is due more to factors involving values, ideology, and decision-making styles” (1977:195). Scientific and user communities may differ because actors have different purposes, rationales, skills and expectations with respect to timeline and results (Naustdalslid and Reitan, 1994). Consulting engineers need knowledge to limit the range of possible outcomes and enable their decision-making within given time limits. Scientists on the other hand are expected to deliver detailed, well-founded and peer review robust results. To consulting engineers, such concern for details may seem to be too time consuming and irrelevant.

Similar arguments are found in a study of energy related building research. Guy and Shove (2000) explore the idea that scientists and practitioners “have their own conventions, definitions and interpretations of relevance and evidence” and state that: “If so, there can be no simple translation between them” (2000:53). In line with these assumptions, they observed that experts’ dissemination strategies (such as experiments, case studies or model simulation) for improving the scientific understanding of energy efficiency among practitioners were not effective. Accordingly, Guy and Shove suggest “the existence of distinctively different knowledge communities, each with their own conventions of evidence, methodology and relevance” (2000:52) and the possibility of a cognitive divide between scientists and practitioners. Thus, knowledge transfer between scientific communities and the consulting engineering industry is made difficult due to communication challenges.

This is supported by the findings of Moncaster et al. (2010) who analyzed how new scientific knowledge was accessed by UK construction industry. However, their study also show that there are many varied knowledge production practices, ranging from the traditional pipeline approach to dissemination from academia to industry through co-production of knowledge. Still, also Moncaster et al. mainly support a two-community theory.

A related perspective is the study of use of new scientific knowledge in industry through the term absorptive capacity. As Cohen and Levinthal (1990: 128) argue, “the ability to evaluate and utilize outside knowledge is largely a function of the level of prior related knowledge”, which constitute a firm’s absorptive capacity. Further, a firm’s absorptive capacity is viewed as dependent on “the individuals who stand at the interface of either the firm and the external environment or the interface between subunits within the firm” (1990:132). Absorptive capacity is also believed to increase when there are (cultural) similarities between the routinely used knowledge and new scientific knowledge to be acquired.

Three perspectives

In contrast to the rather optimistic policy view about science for innovation, the three perspectives outlined above suggest more moderate expectations regarding the acquisition and use of new scientific knowledge in the consulting engineering industry. First, Mode 2 theory suggests that the demand for new scientific environmental knowledge among consulting engineers is produced through their problem-solving practices and limited by economic considerations. Second, Latourian sociology of innovation proposes that innovation may cause demands for new scientific knowledge, but above all that the dynamics of knowledge transfer has to be understood as produced through the translation activities of professors and scientists as well as of consulting engineers offering new services. Third, the two-community theory makes us expect clear cultural differences between scientists and consulting engineers. If this is correct, knowledge transfer would be experienced as difficult because of communication problems between the two communities, unless there is sufficient absorptive capacity at the receiving end.

In the following, I draw on these three perspectives as well as the more optimistic, supply-oriented view from policy-making to analyze more concretely processes and activities among consulting engineers and relevant scientific experts related to transfer, acquisition and use of new scientific knowledge relevant to environmental issues encountered by consulting engineers. Do we find support for the policy-making assumption about science as a driver for the engagement of the consulting engineering industry in environmental issues? If not, what are the challenges? Should we be concerned with the role of higher education rather than research institutions?

Method

The paper is based on three sets of data. The first consists of telephone interviews with one spokesperson from 40 consulting engineering companies. The companies were selected among 275 member companies of the Association of Consulting Engineers in Norway to provide variation in terms of size, type of specialty and geographical location. With respect to size, 14 companies (35 %) had less than 10 employees, 16 (40 %) between 10 and 100 employees, while 10 companies (25 %) had more than 100 employees. In three of the large companies we interviewed in regional offices, varying between small and medium-sized units. This sample is fairly representative of an industry with many small to medium-sized enterprises, but also with a few large and influential firms. The majority of the companies worked with construction and buildings, some specialized in HVAC, project management, etc, while the large companies covered many specialties. The telephone interviews were carried out during a period of two months in 2008/2009. They lasted up to an hour and followed a semi-structured interview guide. The spokespersons were asked about how environmental issues were managed in their company and what they did to implement environmental concerns in their practice. They were also asked about sources of knowledge within as well as outside the company.

The second set of data consists of in-depth interviews with four prominent professors of engineering (called Professors A, B, C and D) and two experienced research scientists (Research Scientist A and B), all working in areas relevant to environmental concerns of the consulting engineering industry. These scientific experts were asked about their interaction with the consulting engineering industry, like shared activities and meeting places. They were also asked about the role of environmental knowledge in the education of engineers.

A third set of data was collected to get an overview of how the consulting engineering industry, including the Association of Consulting Engineers, implements environmental knowledge. We interviewed five prominent people from the industry who were asked about common strategies for managing environmentally relevant knowledge. These interviews have mainly been used as a backdrop to validate the findings from the two other sets of data.

Telephone interviews have been subject to some concerns (Shuy, 2001). They have been criticized for being short and unable to provide “rich enough” material and seen as challenging since they lack non-verbal communication. Also, telephone interviews have been regarded as unable to capture diversity. However, many claim that telephone interviewing is well suited for brief instrumental as well as longer expressive exchanges (Christmann, 2009; Shuy, 2001; Sturges and Hanrahan, 2004). Although we faced issues like the lack of non-verbal communication cues, the data was of high quality. The mix of open-ended and close-ended questions and places to probe made many interviewees elaborate their experiences and views even on close-ended questions, and the interviews came out rich in descriptions.

The professors and research scientists were asked to participate because of their acknowledged expert roles. However, they also served as source of information about a part of the social reality of the consulting engineering industry (Gläser and Laudel, 2009). In this sense, these interviews did not only serve as "just 'information gathering meetings' used primarily for collecting facts and knowledge" (Bogner et al., 2009:5), but took the shape of qualitative interviews based on conversations (Kvale, 1996).

The interviews were taped and transcribed in verbatim, and the quotes have been translated to English by the author. The analysis of the data has been inspired by grounded theory methodology based on open coding (e.g., Strauss and Corbin, 1990). I have been using a software program, ATLAS.ti and developed axial codes for this particular paper based on some of the questions above, for instance about acquisition of new environmental knowledge. From the answers categories across the data were identified, e.g., like 'sources for environmental knowledge' or 'channels for knowledge transfer'. Such categories served as basis for the analysis.

In the following I first analyze how the interviewed professors and researchers interacted with the consulting engineering industry with regard to transfer of new scientific knowledge. What dissemination strategies did they tell about, and what was their relative importance? Then, I analyze how the interviewed consulting engineers accounted for their companies' engagement with new scientific knowledge as well as what they considered to be alternative sources for knowledge needed to address environmental issues.

Supplying environmental knowledge? Dissemination strategies of university professors and research scientists

Findings from previous research represent, as we have seen, an argument that the supply of new knowledge from scientific institutions mainly is an indirect resource for innovation in the consulting engineering industry. This would imply that relevant scientists would experience considerable distance to the industry and that the interaction at best is mediated. However, the interviews with the university professors and research scientists provided a more nuanced picture. All interviewees did engage actively in dissemination of knowledge to the consulting engineering industry. Overall, I observed the use of mainly four strategies in the traffic of environmentally relevant knowledge: (1) Direct collaborations with consulting engineering companies and the industry, (2) The organization of or lecturing at courses designed for consulting engineers, (3) Teaching, thus supplying the industry with new graduates, and (4) The development of standards and new technologies, used by the industry. Some also mentioned participation in public debates but quickly added that such participation was rare. Still, it seemed that scientific knowledge was transferred through the activities of the professors and research scientists. In particular, the assumption of two separate worlds was challenged by the accounts, even of the policy-related optimism received little support.

First, some direct collaboration between professors/scientists and consulting engineers was reported in the interviews but mainly as fairly brief and often informal encounters. As Professor C put it:

> It [collaboration with consulting engineering companies] is sporadic and shaped by your personal relations – whom you know and keep in touch with (…). We meet partly through projects, projects about standards, master thesis work, participation in courses and trade fairs.

Many potential channels of interaction and personal relations were perceived as important. Sometimes projects provided meeting places, but also master theses work that often was done through interaction with industry. What would bring about collaboration activities? Professor D told that if he or his colleagues were asked to contribute to a consulting engineering company, it was usually because the company had encountered problems they could not solve on their own. This is in accordance with the Mode 2-inspired expectation that new knowledge is acquired by consulting engineers through problem-solving in the context of application. However, according to the interviewees, there was more collaboration with scientists working in applied research institutes than with university professors. Probably, this was due to the greater ability of applied research institutes to accept commissions on fairly short notice.

The second strategy involved courses. Some professors and research scientists lectured at courses organized by The Norwegian Society of Graduate Technical and Scientific Professionals and other trade associations. But the effort was seen as limited and the interviewees complained about a lack of invitations to lecture.

Thus, overall, the level of direct interaction as a basis of translating scientific knowledge, in particular among the university professors, was relatively low. Actually, there was a sentiment that professors should not engage in consulting activities – they should do research. Professor C said that: “We try to avoid [the consulting industry], like, we also avoid doing consulting ourselves”. Obviously, there were also constraints with respect to time and resources available to professors/scientists as well as the industry. More prominently, there was a widespread sentiment that knowledge would be disseminated in other ways, above all through teaching. There was a unanimous agreement among the interviewed professors that teaching and the production of graduates was their most important dissemination activity. Professor C said: “Yes, they [the students] are our most important product, all considering”, while Professor D concluded: “Our primary responsibility is to educate candidates”.

In general, the interviewees felt a great responsibility regarding the education they gave their students, including environmental knowledge. There was a shared assumption among the professors that when they provided their students with scientific knowledge, this would be transferred to industry. Thus, translation of scientific knowledge was supposed to happen above all through education.

The fourth strategy was the participation in development of standards and new technologies. This is important since consulting engineers knowledge of sustainable engineering is strongly affected by the new standards and new technologies they have to apply in their practice (Hojem and Lagesen, 2011) and may be viewed as a material mediation of scientific knowledge. Some professors and research scientists participated widely in the setting of standards relevant to consulting engineers:

> I am, and several of my colleagues from my department are part of the national committee responsible for developing standards and regulations. (…) So, we have taken an active part in the development of one of the most important standards within our discipline, which is energy-use in buildings.
>
> (Professor A)

However, even the possibility to participate in such activities was viewed as limited, as most of the professors' time was devoted to teaching and research.

The interviewees described the direct knowledge transfer from the university setting to the industry as limited even if some collaboration did occur. The political expectation, like in *Europe 2020*, is that direct knowledge transfer strategies should work fast and enable an industry like consulting engineers to innovate. However, the scientific experts reported that indirect transfer strategies – above all the training of graduates – were more common than the limited direct collaboration, even if they work more slowly.

Regarding the three theoretical perspectives, the interviewees' accounts raise some issues. The Mode 2 assumption that the importance of problem-solving in the context of application was a limiting feature with respect to demand for scientific knowledge received some support. With respect to Latourian sociology of innovation, we observed that the scientific experts engaged in translation but through strategies rather different from those described for example by Latour (1987). The striking emphasis on education as well as the engagement in the setting of standards and new technologies suggests that the traffic in scientific knowledge needs to be understood differently than the fairly dominant emphasis on direct interaction. This emphasis also raises some issues with respect to the two-community theory: should we assume distinct cultural differences between scientists and practitioners when we know that practitioners are trained by scientists? Perhaps this similarity in education helped to increase the absorptive capacity? To explore these issues further, I now turn to the accounts from the consulting engineering companies.

Consulting engineers appropriating new environmental knowledge

Also the consulting engineers viewed newly educated candidates as important carriers of (environmental) knowledge. They were seen to have the latest scientific knowledge, and this was used in collaboration with more experienced colleagues:

> Initially, nearly all our new employees are educated within Energy and Environmental Engineering at [name of university]. And, our senior consulting engineers have built their environmental knowledge through years of practice. So, the environmental competence is developed in the projects. (…) New employees work alongside the more experienced and knowledge is transferred among the employees.
>
> (CEO, medium-sized company).

Also, as implied in the quote above, when senior and junior employees worked side by side on projects, they would exchange experience and new scientific knowledge. However, the demand for new environmental knowledge appeared to be limited. The CEO of another medium-sized company stated that:

> It's actually quite characteristic for the engineering sciences, I think, not to have a very special focus on environmental aspects? Well, it could be some of our juniors who're newly educated and have been theoretically educated on these subjects. But we're generally instructed by our clients and by the regulations of course.

The main point made by this interviewee was that a demand for new environmental knowledge mainly emerged from requirements made by clients or from regulations, like building codes. Only a few of the spokesperson reported that their company actively promoted environmentally friendly solutions (see also Hojem and Lagesen, 2011). The dominant approach to acquisition of new scientific knowledge relevant to environmental issues was pragmatic – on a need-to-know basis. How did this affect the interaction with relevant scientific communities?

We saw previously that the professors and research scientists reported only a moderate amount of direct contact with consulting engineering companies. This was confirmed by the interviewed consulting engineers. When asked where they got knowledge about environmental issues, many spokespersons pointed to the media while making critical remarks about the (in)accessibility of new scientific knowledge. As a CEO of a medium-sized company said: "In my opinion, there is not very much information coming from the research communities". Still, there was broad agreement that relevant (environmental) knowledge existed in the scientific communities. So, how did they acquire this knowledge when they needed it?

A few interviewees reported direct collaboration with research institutes, and these institutes were described as a resource for scientific knowledge about environmental issues. Moreover, it seemed that it was the consulting engineers that turned to the scientists, not the other way around. Scientists were not perceived as actively doing translation, pushing knowledge into the industry. Also, direct contact seemed to be closely linked to problem-solving in projects, in accordance with the Mode 2 assumption. Research institutes might be hired on a project basis as specialist consultants. Only a few spokespersons reported to be actively seeking information from universities and research institutes independent of their ongoing projects.

Most spokespersons stated that time and cost constraints hampered such acquisition. Even though the interviewees believed that relevant and important knowledge was available in the scientific communities, it was also clear there were challenges in getting hold of relevant knowledge from these communities and that particular skills were required of consulting engineers to be able to communicate with the scientists:

> We work a lot with other actors that have a lot of competence on environmental aspects. And we try to connect with these communities. For example, when it comes to ocean pollution we have established collaboration with [name of research institute],

> where we use their competence [in our projects]. And work together. (…) We have to be knowledgeable to see where our limit is, but we also have to know enough to be able to communicate and be part of a process, participate in the process and drive the processes forward.
>
> (CEO, medium-sized company)

So, as this spokesperson pointed out, fruitful collaboration required that the consultants could identify what scientific knowledge they needed at a specific point in time. In the following, we shall explore further two aspects of the knowledge dynamics of the consulting engineering industry, which impacted the interaction with scientific communities – the pragmatism of knowledge acquisition and the challenges of accessing new scientific knowledge.

Learning by doing? Problem-solving in the context of application

The Mode 2 assumption discussed previously was that the demand for scientific knowledge would be driven by a need to solve concrete problems in a context of application, which indeed is an anticipation of a pragmatic attitude. In accordance with this expectation, the interviewees reported that their most important source of new knowledge was the experience gained through projects. In particular, complex projects were said to offer ample opportunities for learning. The larger, complex projects also provided opportunities to work with and learn from other experts. Especially seniors and so-called "spear-points" – units in the company that had a high level of competence in specialized areas – were regarded as important sources for new environmental knowledge. However, these "spear-points", which mainly were found in the larger companies, seemed to be included only when their expertise was seen as required. However, there were also other mechanisms in use to circulate knowledge in the larger companies. In particular, intranets were emphasized. Consider the following exchange with a group manager:

> R: The company has 550 employees ... If we seek a competence we communicate online. We acquire competence on this and that specialized field.
>
> I: On your intranet, or?

> R: Yes.
>
> I: So you use experts from other parts of the company?
>
> R: Yes. And we do it because the projects are so different. And our employees work on everything from water and sewage, buildings, roads, landscaping, architects … There are so many specialists and disciplines [within the company]. And that makes us strong in many fields. And it’s very easy to just ask. Through the intranet, inquire. And then you get feedback on who’d like to work on these issues and who has the competence.

Since this company had a large number of employees who were specialists covering a wide variety of environmental aspects, it was claimed that knowledge for problem-solving could be found internally. However, this might be an overly positive conception of the employees’ abilities to acquire knowledge from each other. The obstacles reported by many interviewees with regard to external knowledge acquisition, like time constraints and ‘the tyranny of projects’, was also relevant internally.

From the spokespersons’ accounts, we see that the opportunities for acquiring new knowledge mostly were linked to the companies’ everyday practices. The Mode 2-like pragmatism and localism of knowledge acquisition meant that the transfer of new scientific knowledge with respect to environmental issues should be described as demand-led. New scientific knowledge would usually be acquired when there was a felt need but also opportunities, since the acquisition of new scientific knowledge was seen to cost time and money. Thus, Mode 2 theory provides a good insight into the knowledge dynamics of consulting engineering companies, but with the important modification that the resources for problem-solving in the context of application was limited and that access to new scientific knowledge was a challenge. Maybe the relative absence of translation activities from scientific communities reinforced this situation?

Two worlds?

Two-community theory produced the expectation of little direct contact between scientists and knowledge users and little transfer of knowledge between academia and the consulting engineering industry. This situation was assumed to be due to cultural differences. However, on the basis of the accounts of the interviewed scientific experts, the two-community theory was challenged, particularly by noting that it was scientific communities that trained consulting engineers, potentially increasing the absorptive capacity of the industry. This makes it interesting to investigate what the consulting engineers described as their sources and arenas for acquiring (new) environmental knowledge?

To begin with, the interviewed consultants reported limited direct contact with research communities, in accordance with the accounts of the scientific experts. Only a few interviewees reported a need to be updated on current research, not only to tackle problems in ongoing projects, but also to prepare for the future. However, they experienced obstacles. Like a CEO in a medium-sized company told: "I feel [environmental knowledge] is available, but it could probably be even more accessible". What challenges did the consulting engineers tell about with regard to knowledge acquisition?

When new environmental knowledge was in demand by the consulting engineers, there was uncertainty about how such knowledge could be obtained. On the one hand, there was broad agreement among the interviewees that attending courses was an important source of new scientific knowledge for consulting engineers. However, also course attendance was to a great degree influenced by the need for new scientific knowledge in ongoing projects or in relation to new regulations. In the final instance, attending courses was not that important.

Mainly, to know where and how to find environmental knowledge presumably available from scientific communities was described as a challenge. The spokespersons acknowledged that relevant environmental knowledge existed in scientific communities, but they expressed concerns about their ability to acquire and put to use scientific knowledge. When we asked a group manager in a large company about the premises for consulting engineers seeking and adapting environmental knowledge, he pointed to weaknesses with one of the preferred knowledge transfer strategies among professors and research scientists; courses: “Often these courses are about all and nothing».

This interviewee voiced frustration about the knowledge that was presented, which might not be the knowledge they needed. An underlying issue was access. The main concern was not if new scientific knowledge existed, but how it could be retrieved. There was a broad agreement among the spokespersons that acquiring new scientific knowledge was difficult due to the limited availability of scientific research and the time constraints consulting engineers faced when seeking such knowledge. Ideally, they wanted the knowledge needed in their projects to be easily available.

Another challenge was to know what one needed to know. An assistant manager in a medium-sized company said he felt there was some knowledge missing, but without being able to pinpoint exactly what:

> The answer is yes, without knowing exactly what knowledge I miss! But the answer is yes, as these things are constantly changing. It’s not like you can say “I know this now” and be done with it. The world isn’t that static. (…) Yes, we need [scientific] knowledge. If it’s available …? We pick up some here and some there.

Again, we observe the pragmatism. Acquisition of new knowledge was actually the result of a blend of different activities, well described by a consulting engineer from a small company when asked about the sources for (new) environmental knowledge:

> Well, it’s a blend of sources. Some is from our basic education. Some is from the Internet and some is from discussing with colleagues. And from journals, disciplinary journals. (...) Journals on energy sources and energy use. Sustainable energy sources. And our trade association, where we get some input. (…) I actually haven’t attended many courses, but I guess they’re useful too, I really do.

As seen also earlier, courses were not regarded as a main arena for environmental knowledge transfer. This suggests a modest role for professional updating, which otherwise could be expected to be an important driver to acquire new scientific knowledge about environmental issues. This was confirmed when most spokespersons said that professional updating was not regarded as a defined activity or task in their everyday practice. Environmental issues tended to be regarded as a long-term challenge. Time and cost constraints made consulting engineers focus on immediate tasks rather than acquiring knowledge that might be put to use at a later stage. Thus, general knowledge updating seemed limited and closely linked to problem-solving in ongoing projects. An important exception was new governmental regulations, which could spur demand for new scientific knowledge (Hojem and Lagesen, 2011). It is important to note that if governments want to influence the practice of consulting engineers to become more sustainable, it is not sufficient to support and make available relevant R&D. Stricter regulations appear to be more effective in impacting the knowledge dynamics of the industry than R&D.

Troubled dialogue or troublesome practice? The need to combine supply and demand perspectives on transfer of scientific knowledge

In the introduction, I presented policy-makers' optimistic view about science as a driver for innovation and sustainability, voiced in documents like *Europe 2020*. However, as we also saw, relevant scholarly work suggested the need for alternative, more moderate approaches. I chose to present three: Mode 2 theory (Nowotny et al., 2003), Latourian sociology of innovation (Latour, 1987, 1998) and two-community theory (Caplan, 1977; Guy and Shove, 2000; Moncaster et al. 2010).

The empirical analysis gave only modest support to optimistic views of science as a driver of environmental innovations in consulting engineering companies. Acquisition of new scientific knowledge in such companies was basically directed by pragmatic demand, generated through projects and problem-solving in the context of application (Mode 2 theory), not by supply. Apparently, the level of innovation was fairly low (see also Guy and Shove, 2000; Ryghaug and Sørensen, 2009). According to the interviewees, innovation became necessary mainly due to new legal regulations, new technologies, new standards and/or environmental considerations. Availability of new scientific knowledge was less important as a driver of innovation or as a source of inspiration to change current practices.

To what extent was transfer of new environmental knowledge impeded by cultural differences between the scientific communities and the consulting engineering industry? To some extent, two-community theory seems valid in the sense that there was relatively little direct contact between scientists and consulting engineers. Time and cost constraints in projects made consulting engineers focus on immediate tasks instead of acquiring new knowledge or engaging in professional updating. The interviewees agreed that learning usually happened through collaboration with colleagues in projects.

Nevertheless, new scientific environmental knowledge was in demand, but as expected from two-community theory, interviewees expressed concerns about their own ability to identify, acquire and use such knowledge. Time constraint issues were part of this, but there was also broad agreement about the limited or complicated availability of potentially useful scientific knowledge. For example, the courses offered by the scientific communities were regarded by the spokespersons as too general. The interviewees also missed accessible sources of scientific information, like data-bases (see also Moncaster et al., 2010). Thus, the problems related to transfer of scientific knowledge may be in the lack of bridges between scientific and user communities, rather than stemming from cultural differences or lack of absorptive capacity.

The supply-side view, expressed in trickle-down models and other linear theories of innovation, needs to be corrected. However, while the three approaches presented in the paper offer valid insights, in particular about factors influencing the demand for new scientific knowledge, none of them cover the whole complex. Mode 2 theory is too narrowly focused on local activities, Latourian sociology of innovation has little to offer with respect to explaining the absence of innovation, and two-community theory puts too much emphasis on communication difficulties while ignoring the conditions that may create a demand for new scientific knowledge among users.

Thus, we need a more comprehensive sociological theory of science-practice relationships related to innovation and problem-solving in knowledge-intensive services. Such a theory needs to be able to account for the supply of as well as the demand for new knowledge, including local aspects of projects and companies as well as the role of political regulation and business relationships. Also, such a theory needs to be sensitive to the importance of all the indirect roads where new scientific knowledge may be transferred, not the least the importance of newly educated graduates. If public efforts to increase the volume of R&D are to result in greater frequency of sustainable innovations, we need theoretical tools that can replace the seemingly widespread view among policymakers that increased supply of scientific knowledge in itself will lead to increased demand.

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