Knowledge Transfer and Uptake in Design Process of Flood Defences: Case of Kinderdijk-Schoonhovenseveer

Ellen Tromp[1,2], Pieter W.G. Bots[1]
[1]TU Delft, Delft, The Netherlands
[2]Deltares, Delft, The Netherlands
Ellen.Tromp@deltares.nl
P.W.G.Bots@tudelft.nl

Abstract: Although the issue of knowledge transfer has been addressed since the 1970s, the uptake of knowledge in the field of flood risk management is still extremely slow. Innovative techniques for strengthening dikes are scarcely applied, and new insights from scientific research rarely lead to changes in policy. As a result, several opportunities are missed out. The focus of this study is on where and why the transfer and uptake of knowledge fails in the design process of flood defences.

The literature offers three types of explanation for the science–policy gap: misunderstanding, uncertainty, and strategic use of power. Participatory processes can mitigate this, but does not always succeed. Apparently, policy analysts have difficulty designing communicative interactions that will result in a plan with strong stakeholder commitment. A possible explanation is that they lack adequate understanding of how knowledge transfer and uptake in such interactions may fail.

To address this challenge we propose a fine-grained framework for analysing knowledge transfer and uptake in policy processes. This extended sender-receiver framework helps to identify the knowledge need of the receiver, the trustworthiness of the knowledge, and whether knowledge is available. The framework also highlights barriers and failure mechanisms that may hamper the knowledge uptake between a sender and receiver.

Application of the framework to the design process (period 2008-2010) of the dike strengthening case of Kinderdijk-Schoonhovenseveer in the Netherlands diagnosed several barriers. One institutional barrier was that both the water authority, as the external auditor used different institutionalized approaches. A cognitive barrier was that the water authority and the formal reviewer used different technical assumptions. This barrier was eventually overcome by organizing face-to-face meetings to allow metacommunication about these assumptions.

The application has demonstrated that the framework can be used for ex-post evaluation. The next step will be to apply the framework to one or more 'live' cases to see whether it effectively supports process design.

Keywords: knowledge management, science –policy gap, knowledge transfer, knowledge uptake, process design

1. Introduction

Among areas where knowledge management matters, flood risk management (FRM) definitely stands out. A large part of the world's population lives in flood-prone areas such as coastal zones, river plains exposed to coastal or fluvial flooding risks, and lowlands that are susceptible to flooding caused by heavy rainfall or groundwater. Meanwhile, FRM is a complex sociotechnical issue that requires a wide range of expertise from science, engineering, and behavioural disciplines.

In the Netherlands, FRM entails mitigating flood risks by building dikes, dams, and other hydraulic structures to regulate the water. After the 1953 flood, the technical safety standards of the dikes were developed. In 1996, these technical safety standards became statutory (in the Flood Protection Act), and all flood protection structures were to be tested against these standards every 5 (later 6) years. When a flood defence fails to meet the statutory standards, it is placed on the Dutch Flood Protection Programme (DFPP) for future dike strengthening. Local characteristics, such as soil parameters, hydraulic conditions, and the current and desired spatial quality, allow for different dike strengthening techniques. Choices are made via an integrated approach that incorporates disciplines such as water management, spatial planning, and ecology.

As municipalities and private parties seek to realize additional functions (notably housing) on dikes, the spatial integration of the dike in its surroundings is becoming more important. Recently, regulations have changed, increasing the role for the regional water authority as partner in spatial planning. Despite this change and growing pressure from other stakeholders, national and regional water authorities remain conservative: innovative techniques are rarely applied. Although the Netherlands is worldwide leading in FRM research, policy appears inert, and opportunities are missed out. The focus of this study is on where and why the transfer and uptake of knowledge fails in the design process of flood defences.

2. Exploring the science policy gap

The apparent gap between science and policy has been studied for decades. Scharpf (1978) showed that policy formation and policy implementation are the result of interactions among a plurality of actors with separate interests, goals and strategies. Policy making is not a cognitive activity starting with fixed objectives resulting in the best way to achieve these, but rather a continuous open multi-level interactive process. In their 'garbage can' model, Cohen, March and Olsen (1972) show that decisions do not always follow an orderly process from problem to solution, but are outcomes of several independent streams of events. Koppenjan & Klijn (2004) call this phenomenon 'organised anarchy'. Kingdon (1995) shows that decisions not just happen; one can foresee when a 'window of opportunity' opens up. Looking in more detail at this process, Teisman (1992) noted that decision making is an on-going process of interaction, negotiation, and learning that proceeds staggeredly: at certain moments, agreement on some aspect or part is reached, and accepted as basis for a new round of interaction. Within each such round, the lack of knowledge transfer and uptake may be explained by three factors:

1. *Misunderstanding* – Brown & Duguid (1991) showed that expertise is situated; sharing it requires developing shared concepts. Frames of reference are actor-bound, and created through socialisation and experience. Misunderstanding due to frame differences across actors often leads to standoffs in decision-making processes (Van Eeten 1999). If parties have conflicting bodies of knowledge, this leads to controversy and conflict (Van Buuren 2009). To prevent misunderstanding, or resolve controversies, parties need to negotiate some 'common ground' to relate knowledge to their respective disciplinary knowledge.
2. *Uncertainty* – Koppenjan & Klijn (2004) distinguish three types of uncertainty: substantive, strategic, and institutional. Substantive decisions require crisp criteria, whereas scientists typically give bandwidths. Policymakers find it difficult to act upon such uncertain knowledge (Funtowicz & Ravetz 1990). Strategic uncertainty occurs when other actors' positions and actions are unpredictable, while institutional uncertainty occurs when actors cannot foresee to what extent new knowledge can be accommodated in formal regulations and deeply-rooted routines. Weiss (1998, 1979) and Nutley (2003) found that policymakers tend to disregard scientific findings unless these findings are non-controversial, require limited change, or do not upset the status quo (i.e., low strategic and institutional uncertainty). However, the relation between uncertainty and knowledge uptake in policy is not straightforward. Policymakers may strategically use uncertain scientific knowledge to justify decisions, as the general public tends to readily accept and internalize uncertain information as long as it is consistent with current behaviours and beliefs (Bradshaw & Borchers 2000).
3. *Power* – Innerarity (2013) noted that knowledge can be manipulated by those in power to justify decisions. In a field that is dominated by some actor (coalition), this actor can decide which experts to consult and what knowledge to accept. For the expert, this entails a 'speaking truth to power' situation (Wildavsky 1989), whereas the dominant actor can use knowledge selectively for political reasons. When power is polycentric, an expert may be highly appreciated by his/her client, but can be portrayed as a hired gun by his/her client's opponents (Mayer, Van Daalen & Bots 2004). Scientific controversies can therefore add fuel to political disputes. Conversely, different actors seeking to form a dominant coalition can choose to ignore scientific facts blocking compromise, heightening the risk of 'negotiated nonsense' (Van de Riet 2003).

These factors evidently play a role in FRM: the field is multidisciplinary, scientists can estimate soil parameters, flood return periods, and the performance of hydraulic structures under extreme conditions only with limited accuracy, legislation is in permanent flux (Green et al. 2013), the Dutch water sector is territorially and institutionally fragmented, and stakeholders have distinct histories, cultures, and belief systems (Edelenbos & Teisman 2013).

Participatory water management (Von Korff et al. 2012) would seem to address these challenges. Participatory research (Barreteau, Bots & Daniell 2010) interlaces scientific knowledge production and policy making. Participatory processes foster social learning to resolve misunderstanding and institutional uncertainty (Pahl-Wostl et al, 2007). Joint fact-finding mitigates both the abuse of power and the risk of and 'negotiated nonsense' (Edelenbos, Van Buuren & Van Schie 2011). However, all participatory processes mentioned in the literature have limitations. A process designed for 'making sense together' (Hoppe 1999) may lead actors to reach an effective compromise, but in a fragmented field with divergent core beliefs, actors may assemble into competing advocacy coalitions (Sabatier 1988), and persist in a 'dialogue of the deaf' (Van Eeten 1999). A

process designed for 'power-free dialogue' (Habermas 1984; Webler 1995) in which information is shared, and consensus is reached through reasoned argument, rather than the exercise of power, may dissuade powerful actors to commit to its outcomes, or even to participate at all.
Although participatory water management is not a panacea, generic principles for policy process design and management as formulated by, for example, De Bruijn & Ten Heuvelhof (2002) can be operationalized and tailored to the specific interaction moments within a policy process (Bots 2013). To enhance knowledge transfer and uptake, the policy analyst/process designer must be able to diagnose a situation and foresee the consequences of an intervention. The conceptual framework presented in the next section was developed to enhance this capacity for diagnosis.

3. A framework for analysis

Vlachos (1978) was one of the first researchers to address knowledge transfer for water management. Building on his 'linkage' perspective, we conceptualize knowledge transfer and uptake as part of wider context of (development of) reciprocating relationships between knowledge suppliers and users. As shown in Figure 1, in a single knowledge transfer interaction, knowledge K is transferred by a sender S to a receiver R. If a transfer interaction succeeds, K is available to R, meaning that R can choose to use it. By uptake (U) of knowledge, we mean knowledge utilization as defined by Knott & Wildavsky (1980) on a seven-stage cumulative scale that ranges from reception via cognition, reference, effort, adoption, and implementation, to impact.

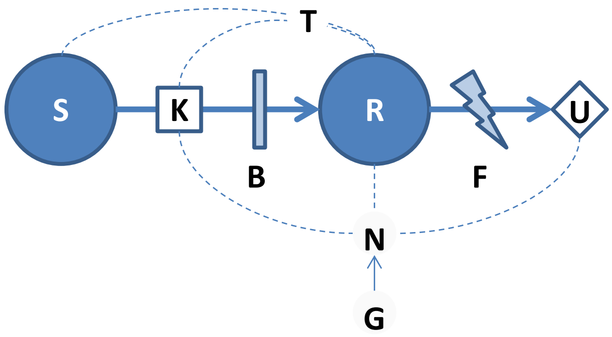

Figure 1: A sender-receiver framework for knowledge transfer and uptake

Three things about this conceptualization should be noted:

1. It leaves open *how* knowledge is transferred. We make no assumptions regarding the nature of K, i.e., whether K can be made explicit, codified, and then communicated, or whether K is tacit, subjective, and must be constructed socially. We adopt Vlachos' term 'transfer' because it expresses the direction from sender to receiver, notwithstanding the observation by Paulin & Suneson (2012) that the term 'knowledge transfer' suggests a 'knowledge as object' view, while 'knowledge sharing' suggests a 'knowledge as a subjective contextual construction' view.
2. In a sequence of interactions, parties can change roles: sender becomes receiver and vice versa, or receiver becomes sender in interaction with a new receiver. By conceptually separating the sender and receiver roles from the actors playing them, we can represent and analyse knowledge transfer processes that occur over time in a network of actors as a series of knowledge transfer interactions. Knowledge exchange between two actors entails that they alternately play both roles, while knowledge sharing in the sense of 'developing shared knowledge' entails that they do so simultaneously.
3. For the upper ranges of the Knott & Wildavsky scale of knowledge utilization (*adoption*, *implementation* and *impact*) to be reached in a single knowledge transfer interaction, the receiving actor must have sufficient discretionary power and resources. In a polycentric governance context, the uptake of K by R will often be limited to *effort*, i.e., R engaging as a sender in interactions with other actors.

Given these clarifications, we identify three preconditions for the transfer of knowledge:

(P1) S must have knowledge K that is relevant to R, and
(P2) S must be willing to share K, which entails that
(P3) S must trust R (Connelly & Kelloway 2000; Davenport & Prusak 1998; Podolny & Baron 1997).

For knowledge uptake U, we identify three more preconditions:

(P4) R must have a particular knowledge need N,
(P5) the knowledge K (partially) fits this need, but is not yet accessible for the receiver, and
(P6) the receiver finds (part of) the transferred knowledge trustworthy.

Levin & Cross (2004) found that knowledge transfer is more effective when the receiver viewed the knowledge source as being both benevolent and competent. We therefore differentiate between two types of trust T for the receiver: benevolence-based trust (the belief that S will not intentionally harm R when given the opportunity to do so) and competence-based trust (the belief that S is knowledgeable about a given subject area). Interpersonal trust (Rotter, 1967) may not be required for the start of knowledge sharing, but it may develop over time as a result of knowledge transfer (Kramer 1999; Ford 2004).
The receiver's need N for knowledge K may have different grounds G. A decision-maker may, for example, commission an environmental impact assessment on substantive grounds (e.g., to improve the design of a dike, or to better understand the risk of a technological innovation), on formal grounds (e.g., because the analysis is required by law), or for strategic reasons (e.g., to defer a decision, or to gain support from some stakeholder group). These grounds may also affect the knowledge uptake.
Knowledge transfer and uptake may be blocked due to three types of barrier:

(B1) *Cognitive* barriers occur when R lacks prerequisite knowledge, or experiences cognitive dissonance, meaning that K does not fit R's understanding of the real world (Festinger 1957). Differences in assumptions and frames of reference, or poor basic communication skills of S and/or R may cause semantic distortion of messages. Based on observations in industry, Carlile (2004) categorizes these barriers along a scale of increasing novelty as syntactic barriers (lack of a common lexicon) and semantic barriers (interpretive differences in concepts). Within his third category, pragmatic barriers that arise when novelty results in divergent interests (when K is "at stake"), we distinguish two different types: B2 and B3.
(B2) *Institutional* barriers arise when R understands K, but cannot act upon it because such action is incompatible with current practices of R, or conflicts with some core values of R or key stakeholders around R. The strength of these barriers is proportional to the inability of institutions to stretch and accommodate proposed changes (Currie & Suhomlinova 2006; Bax, Elvik & Veisten 2009).
(B3) *Resource-related* barriers occur when R foresees financial consequences of knowledge uptake (e.g., when K includes measures that significantly improve safety, but are expensive), or consequential damages of knowledge uptake (e.g., when K concerns a novel technology, or a policy that may lead to legal claims).

Even when these barriers do not arise, or can be overcome, knowledge uptake can fail through fail various mechanisms:

(F1) *Incorrect use*: knowledge K is used by R in ways for which it was not intended by S, possibly for strategic reasons, or because S misunderstood (the grounds for) R's knowledge need.
(F2) *Diffidence:* R interacts with some other actor who by disqualifying knowledge K weakens trust T, which dissuades R from taking up K.
(F3) *No relay*: R does take up K , but the sender in an interaction with some new actor. Uptake of knowledge can fail if this new receiver is not receptive.

4. Case study: dike reinforcement project Kinderdijk–Schoonhovenseveer

We illustrate our framework by applying it to the dike reinforcement project between the villages Kinderdijk and Schoonhovenseveer (KIS). KIS is part of the Lekdijk, which is a primary flood defence that directly protects the hinterland from flooding by the Rhine. The initial expansion of local villages (in the Middle Ages) was concentrated near the dike and around the churches, resulting in ribbon development along the dike (see Figure 2). The Dutch regional water authorities monitor the flood defences that fall under their jurisdiction on a regular basis, and perform periodical assessments as required by law. The Rivierenland Water Authority (hereafter: Rivierenland) is responsible for KIS.

Figure 2: Map of the location of the dike (left), the right picture show the dike with houses, situated in the slope of the dike.

In 2005, the KIS dike section failed to meet the safety criteria, and was hence added the Second Dutch Flood Protection Programme (DFPP-2). Under DFPP-2, dike reinforcement is funded by central government, provided that three criteria are met: projects must be frugal, robust and efficient (DFPP-2 2011). Dutch national policy formally structures a dike reinforcement project in six phases (see Figure 3). At the end of each phase, a plan is formally reviewed before final approval by the DFPP-2 Program Board.

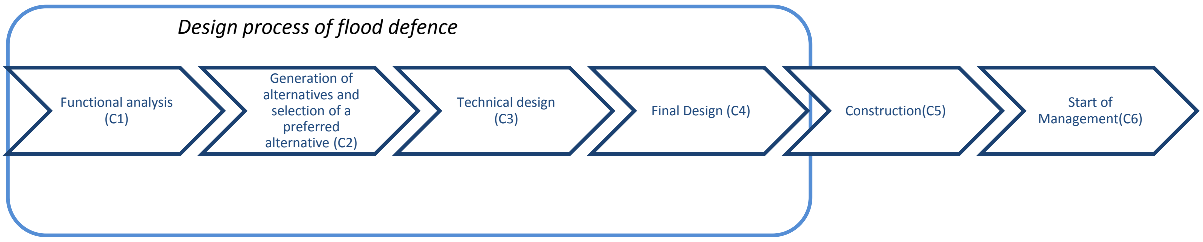

Figure 3: The different phases in a design process of a flood defence

Houses in KIS are typically located within 30m of the dike. The KIS project manager knew how much nuisance dike strengthening projects can cause for residents, so Rivierenland considered using innovative techniques that might reduce it. Their decision-making process comprised numerous interaction moments. To illustrate the application of our framework, we limit ourselves stage (i) in project phase C2: the formal approval of the project plan.

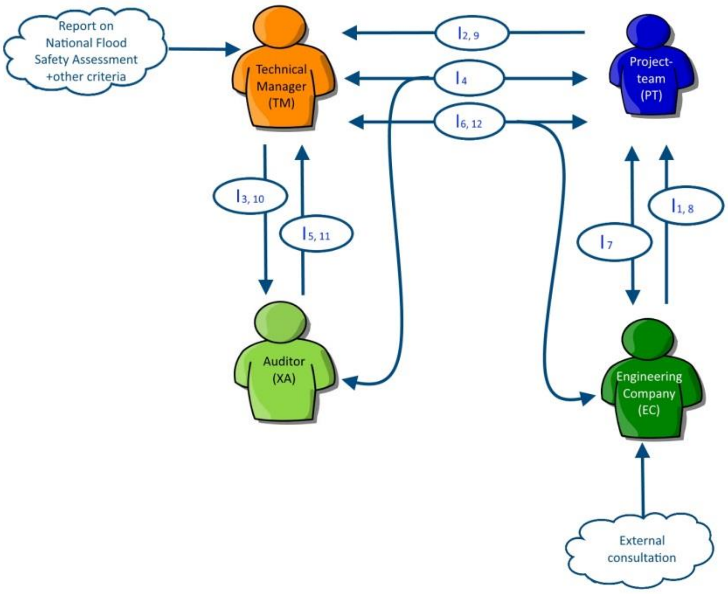

Figure 4: Identified interaction moments in stage (i) between the involved actors

Figure 4 represents 12 interaction moments within stage (i), starting with the engineering company (EC) submitting the dike reinforcement plan to the project team (PT) responsible for delivering this plan to the technical manager (TM) for formal approval (I_1). For want of expertise, the PT accepted the plan without critiquing it, and passed it on to the TM (I_2). The TM found the plan lacking in clarity, questioned several technical assumptions, but nevertheless proceeded with the next step in the formal approval procedure, requesting an external auditor (XA) to formally review the plan (I_3). In this interaction, the TM communicated his concerns, and asked the XA to address these in his review. In a first meeting (I_4) between PT, TM and XA, the PT addressed the highlights of the plan and answered the initial questions by the XA and TM. The XA performed the review by applying the DFPP criteria, and reported back to the TM (I_5). In his report, the XA pointed out strengths and weaknesses of the project plan, and made a range of recommendations. His most important comment was that the deviations from the guidelines were insufficiently substantiated. The uptake of this knowledge was partial, as some recommendations were dismissed by the TM for being incompatible with the constraints of the project (budget, time).

The TM and XA discussed the review with the PT (I_6), indicating which adjustments were essential to meet the criteria. As the PT lacked some prerequisite technical knowledge, the EC also attended the meeting. Part of the plan was demolition of some fifty houses located on the slope and crest of the dike. Being obliged to financially compensate the residents, Rivierenland planned to rebuild some houses on a foundation that can be jacked up, expecting that this would facilitate future dike strengthening. The discussion between TM, XA and PT focused on the question whether rebuilding houses was appropriate for Rivierenland (being a local water authority, not a municipality), and whether the extra costs for foundations that can be jacked up fitted the criterion that projects should be frugal.

The XA also contested the way the EC had determined the height of the crest because the arithmetical approximation of the risk of flooding of an entire dike ring, including a robustness surcharge, differed from official guidelines. As this had led national government to withhold funding in other dike strengthening projects, the TM (and XA) could not be persuaded to use this method. The EC defended his view that that on both points of critique the plan complied with the policy of Rivierenland and national guidelines, but failed to convince the TM and XA. The PT decided to revise the plan, meanwhile reconsidering the assumptions.

In the weeks that followed, the EC met a colleague, who disqualified some of the XA's arguments, and encouraged him to disregard the related recommendations. This affected the subsequent meetings between EC and PT (I_7), where the EC persisted in using a not officially approved database for determining the design water levels, although the XA had found the EC's argumentation unclear, while the effect of choosing another database was unknown.

What then followed was a re-iteration over I_1 - I_3: the EC again submitted the revised plan to PT (I_8). The PT checked whether the agreed changes had been made, accepted the revised plan, and sent it to the TM (I_9). Although the TM still questioned some assumptions, he submitted the plan for review to the XA (I_{10}). The TM noticed that the report on the geotechnical design assumptions was still in draft, and questioned whether the report was detailed enough to pass the review requirements. When reporting back to the TM (I_{11}), the XA emphasized that some recommendations of the first review not been (properly) taken and elaborated in more detail the blanks to fill and the alternative options. Still, the XA found the revised plan more substantiated than the previous one, and expected that it would eventually meet the criteria. The TM then called a meeting (I_{12}) with PT, EC, and XA, to share the findings of the XA. Here, demolition and rebuilding of houses was discussed, and a compromise was found that met the project constraints (time, money, stakeholder needs) while deferring the use of unofficial databases to the next project phase (C3).

In this illustration, the knowledge need precondition for the interactions was typically satisfied on formal grounds: the Dutch national policy prescribes the criteria and the formal project planning and approval procedure, and these define the actors' knowledge needs. In this stage of project phase C2, all pertinent knowledge was available, but required transfer to the actors needing it. The trust precondition was satisfied on different grounds: knowledge sent by private parties (the EC and XA) was trusted on the basis of past performance and reputation; knowledge sent by the TM and PT was trusted on the basis of their public office, and the belief that they perform this office following rigorous procedures. The dominant barriers in this stage were cognitive and institutional. In I_1-$I_{3,}$ we saw that poorly written project plans lead to lack of clarity resulting in misinterpretation of messages. Differences in opinion regarding technical assumptions had the same effect. The lack of prerequisite knowledge of the PT was overcome thanks to the presence of the EC in the meeting with the TM (I_6). An institutional barrier was found in I_6: The dispute between TM + XA and PT + EC was rooted in differences in their respective standard practices and associated assumptions. For the two points of discussion in I_6, no shared view could be reached, as the parties had a different conviction. The parties eventually reached compromise in I_{12} by agreeing to defer both issues to the next project phase. Two failure mechanisms occurred: incorrect use of knowledge when PT and EC misinterpreted the XA's recommendations in I_7, and diffidence after the EC met someone who disqualified the XA's judgement that the method used by the EC was inappropriate.

5. Discussion, conclusion and outlook

In the Netherlands, the dike reinforcement project phases (see Figure 2) are designed according to process management principles: the roles of decision maker and expert are alternately separated and interwoven (De Bruijn & Ten Heuvelhof 2002). In phase C2 of the Kinderdijk-Schoonhovenseveer (KIS) project, the national FRM coordinator (DFPP-2) needed to know, before approving and subsidizing the project plan, whether it met the requirements. An external auditor (XA) performed this review. Given our focus on the *misunderstanding* aspect of the science-policy gap, we used stage (i) of the KIS project phase C2 to illustrate our framework because in this stage the role of *power* and *uncertainty* was limited.

Despite the sensible procedures, communication in this project stage appeared to be difficult. The framework that we propose – tailored to process management in a public policy context, but more fine-grained with respect to knowledge management – helps to classify and diagnose the observed phenomena.
The knowledge needs (N) were highly dependent on policy choices and formal procedures for dike strengthening projects, set by DFPP-2. These procedures bind the XA to rigidly apply criteria to determine whether the project plan complies with the national guidelines. The project team (PT) appeared to use this stage gate in the procedure to *learn*: first to find out the missing blanks in the project plan, secondly to learn from the XA about the interpretation of the national guidelines.
We could test the precondition of trust (T) only through indirect observation. The XA had met the authors of the EC reports on previous occasions, and seen some of their earlier work. From this we infer the existence of a measure of interpersonal trust and competence-based trust between the EC and XA. It is likely that this trust was increased during the face-to-face meetings (Levin & Cross, 2004). This would also explain why – despite the deficiencies in the project plan – both the XA and HWBT-2 agreed that the quality of the reports sufficed to proceed to the next phase (C3 in Figure 2).
Parties had divergent institutionalized approaches for the determination of the height of the crest of the dike. This led them to use the available technical and hydraulical knowledge (K) differently. In addition to this institutional barrier, we also observed several cognitive barriers: lack of prerequisite knowledge, and misunderstanding due to poor writing skills. These barriers (B) persisted because the original procedure prohibited direct contact between the XA and the PT and the subcontracted engineering company (EC) advising the PT. Thus, parties had no opportunity for non-verbal metacommunication (Bateson 2000). The experience (in several dike strengthening projects) that this caused delays led DFPP-2 to revise the procedure. Our observations corroborate that involving the XA in face-to-face meetings led to better comprehension by PT and EC of the XA's critique, and resolved the XA's misunderstanding due to omissions in the project plan documents. Moreover, the face-to-face meetings helped to reach common ground on the interpretation of guide lines.

In sum, the framework that we propose appears to function as intended, as it helped us identify and clarify the uptake of knowledge (or lack thereof) in a FRM planning process. The behaviour of the parties and their interventions are coherent with the diagnosed barriers. We are well aware that applying the framework *post hoc* to the KIS project case gave us the benefit of hindsight. Further research should reveal whether the framework will facilitate (timely) observation and diagnosis of barriers and failure mechanisms in 'live' case studies, and in this way support the design of effective process interventions. Given our ambition to improve the uptake of innovative knowledge in FRM, we expect to benefit from KM research concerning industrial R&D processes. The framework for managing knowledge across boundaries proposed by Carlile (2004), for example, links these barriers to specific capacities that are needed (but may be missing) for effective knowledge transfer. We will need to investigate how and to what extent these ideas can be transplanted from a business context to a public policy context. We also expect that looking through the lens of our sender-receiver model may lead us to better understand the role of 'knowledge brokers' (Meyer, 2010; Hering, 2016). Our biggest challenge will be to relate our findings to those other two dimensions of the science-policy gap: uncertainty and power.

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