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The importance of trust in software engineers' assessment and choice of information sources

Morten Hertzum *

Centre for Human–Machine Interaction, Risø National Laboratory, PO Box 49, DK-4000 Roskilde, Denmark

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Abstract

Engineers such as systems developers get most of their information from colleagues and internal reports. In the literature on engineers' information-seeking practices the generally agreed-upon explanation of this preference for close-by, internal information sources is that engineers follow a principle of least effort by choosing their information sources on the basis of ease of access rather than quality of contents. This study argues that engineers' preference for internal sources such as their colleagues is just as much a preference for sources with a known or easily determinable trustworthiness as it is a preference for information that is easily accessible. Trust is of central importance because quality is a perceived property and, thus, assessing the quality of an information source is essentially a matter of establishing to what extent one is willing to place trust in it. This can be done with greater ease and precision for familiar sources. A field study of the meetings in a software design project shows that in discussing and selecting information sources the software engineers devote significantly more attention to quality-related factors than to cost-related factors. It is also normal conversational practice at the meetings to accompany the mentioning of information sources that may be unknown to some project participants by information that puts them in context. Systems for managing knowledge and sharing expertise must recognise these rich means of forming a perception of the credibility of individual pieces of information.

Keywords: Trust; Information seeking; Communication by engineers; Information sources

* Tel.: +45-4677-5145; fax: +45-4677-5199.
E-mail address: morten.hertzum@risoe.dk (M. Hertzum).

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1. Introduction

Information sharing is a fundamental aspect of engineering work because the design, implementation, and marketing of products and software systems are inherently collaborative activities. Several studies provide evidence that engineers, such as systems developers, spend 40%–66% of their time communicating in order to get input to their work and to issue results from their work (King, Casto, & Jones, 1994). While individual engineers generally prefer face-to-face communication, organisations have a strong interest in handling information in less person-dependent ways than simply relying on the memory and personal files of their employees. This has fostered work on organisational memory and knowledge management to devise ways in which expertise can be captured and shared, along with work on computer-supported cooperative work (CSCW) and information seeking to understand how people go about sharing and making sense of information. This study investigates the importance of trust in software engineers' assessment and choice of information sources. Trust is only a peripheral issue in the extensive literature on engineers' information-seeking behaviour but seems to warrant some modification of entrenched findings.

Engineers' information seeking has been studied extensively over the past 30 years (see King et al., 1994, for an excellent review). Though Pinelli, Bishop, Barclay, and Kennedy (1993) say that "the literature regarding the information-seeking behavior of engineers is fragmented and superficial" it is generally agreed that:

- Internal communication of any kind is more prevalent in engineering work than is communication with sources external to the organisation. Furthermore, engineers tend to rely on their own information and on colleagues before the library and other internal sources.
- The cost associated with the use of an information source is the most important determinant of its use. That is, in selecting among information sources engineers seem to follow a principle of least effort and thus counter any assumption of information quality as the criterion upon which source selection is based.

While the first statement is an observable behaviour — an empirical fact — the second is an explanation of this behaviour in terms of the cognitive rationale that leads to it. This study argues that the concept of trust provides an alternative explanation of engineers' preference for close-by, internal information sources. The key to this argument is outlined in the next section on the concept of trust. Then, Section 3 reviews the studies giving rise to the least-effort principle and Section 4 replies with a review of studies providing evidence that close-by, internal sources are perceived as more trustworthy than other sources. Section 5 reports from a field study investigating what software engineers pay attention to in assessing and choosing information sources. The results indicate that the software engineers in the studied systems development project can most confidently assess the trustworthiness of information from sources with which they are familiar. For this reason and to increase the likelihood of an answer tailored to the situation in hand the engineers tend to prefer information

sources with which they already have relations. In conclusion (Section 6), it seems at least as important to provide access to information in ways that allow people to confidently assess its trustworthiness as it is to make information accessible at low cost. This may have severe implications for the design of systems intended to support information sharing.

2. The concept of trust

The quality and credibility of an object, a person, or a piece of information are not properties inherent in the object, person, or information. Rather, quality and credibility are perceived properties (Tseng & Fogg, 1999). Thus in looking for information of high quality, engineers are looking for information that is (1) accessible in a way that enables the engineer to form a perception of its quality and (2) perceived to be of high quality. The first step is necessary because the quality of the information does not reside in the information as a label that can be read but has to be established actively by the individual engineer. Establishing the perceived quality of a source or piece of information is essentially a matter of establishing to what extent one is willing to place trust in it.

Siemieniuch and Sinclair (1999) identify trust — rather than technical quality, expertise, or management — as the real glue that binds a company together. Thus, trust is a fundamental aspect of cooperative work and is at play whenever people exchange information. In relation to human–human interaction trust is mostly defined as an emotive issue where the trusted party has a moral responsibility toward the trusting party. To the trusting party trust involves an assessment of whether the other person possesses the required knowledge and skills (does she know?) and is likely to give a truthful and unbiased account of what she knows (will she tell?). Finally, the decision to place trust in something requires that the trusting party has sufficient confidence in his ability to correctly interpret the communicated message to be ready to rely on it in his future work (do I understand?). People place trust in each other to varying degrees, depending on numerous situational factors. They know their sources to be reliable in some domains but not in others, they collect multiple sources of evidence to safeguard themselves against actors with inadequate capabilities or deceiving intentions, and they engage in a lot of communication to build and maintain a network of people they can turn to for advice and inside information. Tseng and Fogg (1999) distinguish four types of trust by means of the evidence on which the trust is founded:

- First-hand experience (e.g., interacting with people over time, we assess their expertise and trustworthiness).
- Reputation; that is, what third parties have reported (e.g., asking someone for advice based on having her recommended by a colleague).
- Simple inspection of surface attributes (e.g., assessing people by the way they dress or the language they use).

- General assumptions and stereotypes (e.g., believing that your friends tell the truth, whereas car salespeople do not).

The four types of trust differ with respect to the amount of evidence involved. Thus, knowing an information source first-hand or knowing someone who knows it first-hand provides people with a more solid basis for assessing the trustworthiness of the source. In line with this Van House, Butler, and Schiff (1998) find that trust is rooted in communities of practice and several studies have found that the physical or organisational distance between people affect their readiness to trust each other (see Section 4). This way the concept of trust challenges the least-effort principle by suggesting that engineers' preference for internal sources such as personal files and colleagues could be just as much a preference for sources with a known or easily determinable trustworthiness as it is a preference for information that is easily accessible.

3. The least-effort principle

The information sources available to engineers differ along a number of dimensions, such as oral versus written, in-house versus external, lay versus authoritative, fact versus opinion, and whether they contain information or pointers to information. Cutting across this multitude of information sources and an equally varied web of information needs, numerous studies find that engineers generally tend to rely on internal information sources such as their colleagues and personal files, as opposed to libraries and sources external to the organisation (e.g., Bichteler & Ward, 1989; Bishop, 1994; Shuchman, 1982; Von Seggern & Jourdain, 1996). As an example, Bishop (1994) studied 950 aerospace engineers' responses to a survey about their use of electronic networks to access information sources. In terms of people sources the network was used to communicate (primarily by e-mail) with people in one's workgroup or department (88%), other people in the organisation (89%), colleagues in academia and government (72%), colleagues in private industry (62%), external clients, customers, and sponsors (58%), external vendors and suppliers (52%), and other people (22%).

A number of studies have investigated the reasons for engineers' general preference for close-by, internal sources. These studies report that technical quality, degree of experience with the source, and the cost associated with using the source (i.e., its accessibility and ease of use) affect engineers' choices of information sources but that the cost is the most important determinant of source use. Major reviews of engineers' information-seeking behaviour have stated:

- "Clearly, most communication researchers have shown that ease of use or time required dictates information sources used by engineers." (King et al., 1994)
- "The relevant literature overwhelmingly favors accessibility as the single important (variable) determinant of use." (Pinelli et al., 1993)

Following Zipf (1949) this is known as the least-effort principle and it counters any assumption of information quality as the main criterion upon which source selection is based. Below follows a brief review of three studies that have looked systematically at the factors affecting engineers' information-seeking behaviour and reported evidence of the least-effort principle.

Gerstberger and Allen (1968) considered four factors in engineers' choice of information sources: accessibility, ease of use, technical quality, and degree of experience. Over a 15-week period 19 electronics engineers were periodically asked to rank nine information sources (experimentation, group, technical staff, company research, other division, literature, customers, vendors, and other external sources) according to the four factors. The results show a strong relation between accessibility and frequency of use (r=0.67), a somewhat weaker relation between ease of use and frequency of use (r=0.44), and a weak relation between technical quality and frequency of use (r=0.28). When accessibility is held constant both ease of use and technical quality show little relation with frequency of use. Further, the engineers' perception of accessibility seems to be influenced by their experience: The more experience an engineer has with an information source, the more accessible it is perceived to be. Gerstberger and Allen conclude that "apparently, in the minds of the [studied engineers], there is some relation between their perceptions of technical quality and channel accessibility, but it is the accessibility component which almost exclusively determines frequency of use". Allen (1977) revisits this study and remarks that there is a slight correlation between technical quality and accessibility. This is in line with the engineers' perception. Allen argues that the weak relation between technical quality and frequency of use is illusory and appears only as a result of the mutual relation with accessibility. In relation to the present study it is noteworthy that familiarity with a source may increase both its accessibility and its perceived quality.

Rosenberg (1967) had 96 professionals (52 in research positions and 44 in industrial non-research positions) rate a number of information sources on a seven-point scale with respect to ease of use and amount of information expected. The professionals also ranked the information sources according to personal preference in three hypothetical situations. The results show a strong, statistically significant correlation between preference and ease of use for both researchers and non-researchers (r=0.87 and r=0.88), whereas no correlation was found between preference and amount of information expected (see Table 1). The information source "Search your personal library" ranked highest on preference, ease of use, and — for the non-researchers — amount of information. However, in rating the information sources the only cue available to the respondents was the wording of the descriptions of the sources. Four of these descriptions contained the phrase "a knowledgeable person" but differed with respect to whether the communication with this person should be by visit, telephone, or letter. It gives cause for concern that the respondents expected more information from writing a letter and talking on the phone than from visiting the knowledgeable person. While the respondents may perceive that the channel influences the outcome of the communication in this way, it seems more likely that they have not been able to completely separate amount of information expected from ease of use.

Table 1
Information sources ranked, study by Rosenberg (1967)[a]

Information source	Preference ranking		Ease of use ranking		Expected amount of info. ranking	
	R	NR	R	NR	R	NR
Search your personal library	1	1.5	1	1	3	1
Search material in the same building where you work, excluding your personal library	2	1.5	2	3	7	7
Visit a knowledgeable person nearby (within your organisation)	3	3	4	4	5	8
Consult a reference librarian	4	5	5	5	4	3
Use a library that is not within your organisation	5	6	6	7	8	6
Telephone a knowledgeable person who may be of help	6	4	3	2	2	4
Write a letter requesting information from a knowledgeable person — 20 miles away or more	7	7	7	6	1	2
Visit a knowledgeable person — 20 miles away or more	8	8	8	8	6	5

[a] R=researchers, NR=non-researchers

Chakrabarti, Feineman, and Fuentevilla (1983) considered six factors in engineers' choices of information sources: cost to use, skills to use effectively, utility of information, availability, ease of use, and frequency of use. A total of 500 engineers working in different industrial sub environments rated a number of information sources on a five-point scale with respect to each factor. The results show statistically significant correlations between frequency of use and each of availability (r=0.88), ease of use (r=0.82), cost (r=−0.63), and utility (r=0.57). Again, availability and ease of use are the strongest predictors of frequency of use. However, the data also show a correlation between availability and utility (r=0.47). As in Gerstberger and Allen (1968) above, this correlation hints that the more easily available information sources may at the same time have qualities that make them more rewarding in terms of perceived utility or amount of information expected.

4. Trust and assessment of information sources

The extent to which an engineer is willing to place trust in an information source can only be determined if the source is accessible in a way that allows the engineer to form a perception of its quality. This is difficult, at best, when the only information available about the source is that it is "a knowledgeable person — 20 miles away or more" (Rosenberg, 1967). More generally, survey-based studies such as Chakrabarti et al. (1983), Gerstberger and Allen (1968), and Rosenberg (1967) tend to underplay the extent and richness of the process that goes into making sense of objects

and events. Thus, these studies of factors that affect engineers' information-seeking behaviour seem to some extent to discard that to assess the quality of an information source it must be available in a way that allows for quality assessment. Instead, these studies adopt a more aggregated, context-free notion of technical quality.

Several studies of trust analyse issues of key importance to the choice of information sources. Below follows a brief review of three studies reporting that (1) people within an organisation, (2) people from the same function within an organisation, and (3) people who are physically co-present are perceived as more trustworthy than others. Collectively these studies suggest that choosing the information sources that are perceived to be the most trustworthy leads to a preference for the same sources as a choice based on the principle of least effort.

Zucker, Darby, Brewer, and Peng (1996) studied how organisational boundaries affect trust production within biotechnology. In this area cutting-edge discoveries have a high scientific and commercial value, and consequently trust is extraordinarily important in communicating such discoveries. On the one hand collaboration may lead to faster progress and better exploitation of a discovery. On the other hand collaboration means giving up exclusive access to the discovery. Zucker et al. argue that social agency — an activity that is costly because it requires human time, attention, and resources — is required to produce trust. Thus, some possible collaborators may be ruled out because their trustworthiness is too costly to establish compared to the alternatives. Zucker et al. extracted information regarding 327 top scientists and their 7825 co-authors from a virtually complete record of the discoveries in a specific sub area of biotechnology between 1967 and 1990. The results show that the scientists' collaboration behaviour has gradually changed in a way that is consistent with the initial high value of a discovery and subsequent decline of its value: (1) Early in the process, more co-author pairs are located in the same organisation, suggesting that within-organisation collaboration has been used to limit information flow. (2) Over time, the number of co-author pairs increases such that wider access is gradually being given to the discoveries. Zucker et al. conclude that belonging to the same organisation appears to be a powerful and effective means of generating trust and, conversely, that distrust appears to be one of the major costs involved in collaboration across organisational boundaries.

Moenaert, Deschoolmeester, De Meyer, and Souder (1992), studied the communication between marketing and R&D (research and development) personnel in 80 planning or development projects. A total of 386 people (61% from R&D, 39% from marketing) responded to a questionnaire by rating information they had recently received from the other function (i.e., from marketing if the respondent was from R&D, and from R&D if the respondent was from marketing). The respondents rated the received information according to 13 indicators of its credibility, relevance, novelty, and comprehensibility. The results show that whereas these four factors all contribute to the perceived utility of the received information, the credibility and relevance factors are the most important determinants of perceived utility. Moenaert et al. interpret the importance of the credibility factor as an indication that people tend to adopt a rather taciturn attitude when they are confronted with information from the other function. In fact, 16% (61 out of 386) of the respondents indicated

that they had never communicated with the other function. Moreover, information from people who have previously worked in the same function as the receiver but have moved to the other function within the last five years is perceived as more comprehensible but less credible. After at least five years in the other function it seems as if the movers have established themselves, and they are no longer perceived as less credible. Thus, since people more readily trust colleagues from their own function than people from other functions, it seems as if people from other functions are further away in psychological terms — just as they are often further away in physical terms.

Valley, Moag, and Bazerman (1998) studied the different degrees of trust and truth-telling in bilateral bargaining depending on the media used for communication: face-to-face, telephone, and written messages. A total of 69 pairs of undergraduates participated in an experiment where one assumed the role of seller, the other that of buyer. While the seller knew the actual value of the item on sale, the buyer did not. With this asymmetry as their point of departure the buyer and seller, who did not previously know each other, were asked to settle on a price. The results show that the type of outcome varied significantly across the communication conditions. The most frequent outcome in face-to-face communication was mutual gain; in telephone communication it was that the buyer agreed to pay more than the value of the item; and in written communication that no agreement could be reached. Sellers were significantly less likely to lie face-to-face than in telephone negotiations ($p<0.005$), and somewhat less likely to lie face-to-face than in writing ($p=0.06$). About one third of the written negotiations contained no discussion of value by either buyer or seller and basically proceeded as a series of bids and counter-bids. The buyer trusted the seller enough to make a bid based on the seller's representation of the value of the item in 79% of the face-to-face negotiations, 55% of the telephone negotiations, and 33% of the written negotiations. Thus, from the buyer's point of view face-to-face negotiations are clearly preferable since telephone negotiations are less trustworthy and more likely to result in an unfavourable deal, and written negotiations tend to result in less information being exchanged and more negotiations reaching an impasse.

5. Trust in the CSA project

To be able to support the assessment of source trustworthiness in effective ways we need an in-depth understanding of how actors in concrete cooperative work settings assess the trustworthiness of information sources and how much importance they attach to trustworthiness compared to other things. While the previous studies of the factors that affect engineers' choices of information sources have mostly relied on questionnaires asking engineers to rank order a set of sources, the following is a field study. The purpose of the field study is to investigate whether it is true that engineers attach key importance to being able to assess the trustworthiness of their information sources and how this manifests in their information-seeking behaviour.

5.1. The CSA project

The company where the field study took place is a large software house, which has developed and marketed a range of systems for use in local government institutions. The project analysed in this study concerned a system to support local government authorities in the handling of cases concerning child support and alimony (CSA). The CSA project was initiated in 1999 and will, according to the project plan, last three years. The first eight months of the project, the period analysed in this study, concerned the requirements specification and the business modelling. During this period the project was staffed with a project manager, eleven designers/developers, two service consultants, a methods and tools consultant, a usability specialist, and a secretary. The project manager and six of the designers/developers worked full time on the CSA project, the remaining ten persons were assigned to the CSA project on a part-time basis. In the following the members of the CSA project will be termed CSA engineers, irrespective of their different educational backgrounds.

The CSA engineers are to completely redevelop the existing CSA system, which several of them have been heavily involved in developing and maintaining. Whereas the existing CSA system contains substantial amounts of code that duplicate functionality from other systems made by the company, the new CSA system will distribute this functionality onto components that are to be developed outside the CSA project. This philosophy of component-based design means that the CSA engineers have to cooperate closely with a number of people inside the company to negotiate, settle, and follow up on component definitions and how the development of the components progresses. Naturally, the CSA engineers also have to interact with management, marketing, the quality function, and so forth to accomplish their task. Moreover, they have to communicate with external stakeholders such as user representatives and the governmental bodies responsible for the laws regarding child support and alimony.

5.2. Method

The data collected for this study cover the formative eight-month period from the initiation of the CSA project, through the requirements specification, to the completion of the business modelling. I have followed the project by (1) participating in the two-day start-up seminar, (2) being present at the fortnightly project meetings and some additional meetings, (3) conducting interviews with eleven of the core project participants, and (4) inspecting various project documents. This study is based on an analysis of the 16 meetings that have been observed, whereas the other empirical data provide background information.

The main purpose of the meetings was to provide a forum for sharing information about the status of the project, maintaining awareness of the entire project, co-ordinating activities, discussing problems and progress, making decisions, and reviewing major project documents. During the meetings I was seated at the meeting table with the other people present. From their point of view I have been invisible in that I

was not to be spoken to and have myself remained silent. During the breaks I have talked informally with people. All the meetings have been recorded on tape and transcribed.

The data analysis involved two passes. First, nine transcripts were examined sentence by sentence and all references to information sources were marked up and annotated. Based on this bottom-up analysis a coding scheme was created. Second, all 16 transcripts were examined to identify the incidents where information sources were discussed, selected, or referred to. These incidents were then coded with respect to the resulting categories, which concern the type of information source and the most important reason for discussing, selecting, or referring to it. The coding regarding type of information source simply distinguishes between *people sources*, including project groups and organisations, and *document sources*, including information systems. The coding regarding the reason why an information source received attention employs a primary distinction between quality-related factors and cost-related factors. Initially, this coding contained four factors drawn from previous studies: *technical quality*, *accessibility*, *ease of use*, and *cost to use*. While this was sufficient to cover the cost-related aspects, the initial analysis of nine transcripts gave rise to additional quality-related factors. These factors have to do with whether the source has the appropriate formal or practical background and with the fit between this background and the current situation. The resulting coding distinguishes between twelve factors (see Table 2).

5.3. Findings

The 16 meetings included 580 incidents where the CSA engineers' attention was devoted to discussing, selecting, or referring to information sources (see Table 3). On average the meetings contained such an incident every 3.6 minutes but the incidents often appeared in clusters because several CSA engineers made different contributions to the description and assessment of a source. For the people sources the single factor most frequently involved in the choice of information source was *appropriate organisational unit*; for the document sources it was *accessibility*. The factor with the lowest overall frequency was *cost to use*.

Overall, 75% of the incidents involved people sources. This is significantly more than the incidents involving document sources ($p<0.0001$). The CSA engineers often arranged meetings to get feedback on design ideas from people external to the project, and in preparation for such meetings they often wrote and distributed documents to allow the participants to prepare themselves. In these situations the documents were supplementary sources intended to improve the quality of the primary face-to-face communication with the people sources. Further evidence that documents were often merely supplementary sources was provided by a couple of incidents in which CSA engineers sought expert advice after having studied the authoritative written legislation. Expertise was required to interpret these texts competently, and since the CSA engineers did not possess this expertise they preferred seeking expert advice to relying on their own interpretation. Thus, even though the legislation was available

Table 2
Categorisation used for coding why information sources were discussed, selected, and referred to

Factor	Description	Sample incident
Quality-related factors		
Appropriate organisational unit	The source comes from the organisational unit formally vested with the right authority and competence	*I have asked [a person from the legal department] for a meeting regarding the issue of how we assemble the application from [system-size] components without infringing fair-competitiveness regulations.*
Appropriate project experience	The source has hands-on experience with the issue from past or ongoing projects	*They haven't tried it themselves. This sounds kind of pseudo as they actually haven't tried themselves.* *I tend to agree but those close to them say they have plenty of experience, and we are not in a position to discard that, so we won't.*
Appropriate external body	The source comes from the external organisation formally vested with the right authority and competence	*Then there is [an issue regarding legal practice]. [A person from the Ministry of Justice] said he was willing to take care of that, on our behalf, by raising it with one of his colleagues in the ministry.*
Appropriateness to task	The goodness/badness of the fit between the source and the task, i.e. focus is on the relation between source and task, not on the source as such	*You have had the wrong consultant — at the wrong point in time. You should have had a business modeller in the beginning, to help you make the business model. And you haven't had that.*
Technical quality	The high/low technical quality of the information that can be obtained from the source, irrespective of the genesis and appropriateness of the source	*She cannot programme.*
Up-to-dateness	The up-to-dateness/outdatedness of the information provided by the source	*He is still circulating his experiences from [an old project] but I don't know whether that knowledge is outdated.*
Representativeness	The extent to which the source is representative of the group it belongs to	*We have to be good at asking other people than [two of the user representatives]. Don't get me wrong: They have that area only and they are very competent and careful. But they are not always representative of an average user in an average municipality.*

(continued on next page)

Table 2 (*continued*)

Factor	Description	Sample incident
Cost-related factors		
Accessibility	The ease/difficulty involved in getting access to the source	*It is those CICS statistics I'm thinking of. Can we use them? We made those statistics for [a government institution] so they are readily available.*
Ease of use	The cognitive ease/difficulty involved in using the source once one has got access to it	*I know a lot of people don't communicate that well with [a person] but that is the kind of thing we have to try to work around. If we give primacy to the task we should be able to focus on that rather than on personal issues.*
Cost to use	The small/large amount of material and physical resources required to use the source	*If we had to do this ourselves we could easily spend three weeks on it. Those who have used [an internal consultant] say that really saved them some time. She can immediately tell us the consequences of doing like this or like that.*
Other factors		
Background	General or specific background information about the source provides more basis for assessing it	*I have a meeting with [a person] today. He has previously been head of service in a department in [another part of the company]. He is still in [that part of the company] but now as a project manager.*
Other	Everything that does not fit into any of the above categories	*They talked against you. That's people who approach their task in the right spirit.*

Table 3
Factors affecting the assessment and choice of information sources

Factor	People sources	Document sources	Total
Quality-related factors	**281 (64%)**	**78 (54%)**	**359 (62%)**
Appropriate organisational unit	64 (15%)	9 (6%)	73 (13%)
Technical quality	55 (13%)	11 8%	66 (11%)
Appropriate project experience	59 (14%)	2 (1%)	61 (11%)
Appropriateness to task	40 (9%)	20 (14%)	60 (10%)
Appropriate external body	45 (10%)	10 (7%)	55 (9%)
Up-to-dateness	10 (2%)	17 (12%)	27 (5%)
Representativeness	8 (2%)	9 (6%)	17 (3%)
Cost-related factors	**61 (14%)**	**43 (30%)**	**104 (18%)**
Accessibility	37 (8%)	28 (19%)	65 (11%)
Ease of use	12 (3%)	12 (8%)	24 (4%)
Cost to use	12 (3%)	3 (2%)	15 (3%)
Other factors	**94 (22%)**	**23 (16%)**	**117 (20%)**
Background	57 (13%)	11 (8%)	68 (12%)
Other	37 (8%)	12 (8%)	49 (8%)
Total	**436 (100%)**	**144 (100%)**	**580 (100%)**

and had been studied by the engineers the limited trustworthiness of their interpretation of it made the engineers seek more competent people's advice.

A total of 62% of the incidents were concerned with quality-related factors, whereas the remaining incidents were divided about evenly between cost-related factors and other factors. This tendency to give more consideration to quality-related factors was significant overall ($p<0.0001$) and for the incidents concerning people sources ($p<0.0001$) but not for the incidents concerning document sources ($p=0.18$). Thus, the assessment and choice of people sources was dominated by quality-related factors whereas the document sources displayed a more even balance between quality-related factors and factors related to costs and other things. This could be another indication that the project primarily relied on its people sources and, thus, gave much consideration to their trustworthiness. Alternatively, it could be an indication that people sources were brought to the group's attention in large numbers and thus some pruning was needed, whereas documents were brought up more sparingly and only when their appropriateness was more or less evident. While we cannot make strong claims about why the quality-related factors played a more prominent role in relation to the people sources this difference does reflect that people and documents were experienced as different types of sources, which had to be treated differently.

In the beginning of the CSA project many of the projects, departments, and other information sources that were mentioned at the meetings were unknown to some of the participants. On a number of occasions speakers were asked who worked on that project, whether that was the department where this person worked, or what that person's background was. Similarly, several speakers volunteered such context information. Thus, it was a well-established conversational practice to accompany the mentioning of information sources that might be new to some project participants

with information that put these sources in context or with explicit statements about their expertise. This served to inhabit new information sources, such as project groups, with known people who could lend the source an initial face and grounding.

On being introduced to new information sources, the CSA engineers experienced it as important to get a feel for the persons they would be dealing with. Seemingly, this "need for names" was central to their ability to assess the credibility of an information source. The need for names was particularly evident in the negative cases where trust was breaking down. Example: In discussing why a much needed upgrade of the CSA engineers' computers with new software had not yet taken place, even though it had been done in other parts of the company, the methods and tools consultant said:

> *Normally, I wouldn't consider it a problem that [the upgrade] has not yet started. What I do consider a problem is that I have not been able to get the names of the persons who are going to perform the upgrade in this part of the company.*

Without a name it seems as if nobody is responsible for carrying out the activity or, in the case of a source that merely provides information, for the correctness of the information. Conversely, knowing the person provides the activity or piece of information with a history in that it becomes possible to use knowledge of the person's previous achievements as a basis for assessing the current activity or piece of information. Such credibility assessments are an integral part of a multitude of activities, for example Symon, Long, and Ellis (1996) quote a hospital doctor for saying that in the process of deciding what he thinks of a report he always looks for the name of the author.

Looking specifically at the people sources, the CSA project drew on several organisational units that have been established to support development projects in getting their work done. This included technical services, the usability laboratory, the legal department, and the quality function. These units have formally been vested with the authority and competence to handle certain issues. Likewise, the CSA project drew on several authoritative external bodies such as the group of user representatives which embodies comprehensive experience in the practical handling of CSA cases and the governmental bodies responsible for the laws in the area. While it is mandatory to involve some of these sources, most of them were involved because the CSA project decided to use them. In both cases CSA engineers had to form an opinion about whether they considered these people to be in possession of the required knowledge and skills. A number of the incidents concerning *technical quality* were directed at establishing whether the sources appointed to handle certain issues were at the same time sufficiently competent and, thus, trustworthy. In this regard there was a certain tension between formal expertise and hands-on experience. Several of the CSA engineers were somewhat reluctant to trust appointed experts, and generally preferred to talk to colleagues who had experience with an issue from actually working with it. The formal experts were not without experience and, thus, this was far from being a black and white distinction but hands-on experience appeared to be a stronger way of gaining trustworthiness than being a formally

appointed expert. Nochur and Allen (1992) find that the formally appointed experts in their study were not effective in transferring technologies to the technical staff, and suggest that the appointment increased the experts' contact with sources knowledgeable about technologies (such as the corporate research centre) but not necessarily their contacts with the technical staff who were to use the technologies. This becomes critical to their success as gatekeepers because the technical staff is more likely to turn to a person for help if they know enough about this person to believe that she will be able to help them.

It testifies to the subtleties of engineers' information-seeking behaviour that appointing someone an expert can turn out to reduce the likelihood that others will rely on him or her for information. Instead of appointed experts, the CSA engineers displayed a preference for people with hands-on experience from projects comparable to the CSA project. For the people sources such experience from appropriate projects was a top-ranking factor. Finally, it may be noted that being out of date is a serious threat to the trustworthiness of documents — including systems for managing knowledge and sharing expertise — but hardly an issue in relation to the CSA engineers' assessments of people sources (see Table 3).

5.4. Discussion

One could argue that prior to what goes on at the meetings the engineers in the CSA project have tacitly agreed to restrict themselves to sources that are easily accessible; that is, primarily internal sources and sources that are known in advance. If this is true, cost may be the primary determinant of source selection even though it is the quality-related factors which receive most attention at the meetings — the engineers have simply learned to consider only the low-cost sources. Conversely, Orr (1970) proposes that often engineers need only a small amount of good-enough information and that this leaves them free to choose their sources based on cost (as most studies find they do) since several sources will satisfy their needs. If this is true, quality is the primary determinant of source selection even though it is often secondary factors such as cost which lead engineers to prefer one good-enough source to another. Cost and quality are, however, only available to engineers as perceived cost and perceived quality, they are not absolutes. As argued above, this brings cost and quality closer together in that they both introduce a bias toward familiar sources.

Without implying that cost is unimportant, this study provides evidence that perceived quality — trustworthiness — is important to engineers' choice of information sources. The amount of attention devoted to trustworthiness could further indicate that trustworthiness is often more difficult to assess than cost. By attributing engineers' choice of close-by information sources solely to cost, the least-effort principle wrongly neglects the importance of trust. This bias toward cost has been carried over into numerous systems development efforts.

Many efforts to provide computer support for cooperative work have focused on making documents available anywhere and anytime; that is, on reducing cost. The CSA project clearly illustrates that simply making information sources available does

not provide engineers with the information they need in assessing and choosing their sources. Without information that enables the engineers to form a perception of the quality of the offered information they will experience profound difficulties in relating to it. This leads to a preference for other sources and illustrates the gap between having information available and being informed by it (Hertzum, 1999; Kidd, 1994; Mintzberg, 1975). Recognising both the importance of trust in engineers' choice of information sources and the difficulties of representing source trustworthiness in information systems, one possible way could be to refrain from such representation and rather provide links to documents *as well as* people. Hertzum and Pejtersen (2000) find that engineers routinely get the information they need in order to assess document trustworthiness by having colleagues recommend them which documents to read and by contacting document authors rather than actually reading documents. This suggests that supplementing document management systems with facilities for people finding could be a way to provide possibilities for determining source trustworthiness.

6. Conclusion

To design systems that support cooperative work by providing shared access to pertinent information it is important to understand engineers' information-seeking practices. In the literature, engineers — such as systems developers — have repeatedly been found to rely on oral communication and information sources internal to their organisation before written communication and external sources. The generally agreed-upon explanation of this finding is that engineers follow a principle of least effort by choosing their information sources on the basis of ease of access rather than quality of contents. This study argues that engineers' preference for internal sources such as their colleagues is just as much a preference for sources with a known or easily determinable trustworthiness as it is a preference for information that is easily accessible.

Quality is a perceived property, not something inherent in an information source or a piece of information. Thus, in looking for useful information, engineers are looking for information that is (1) accessible in a way that enables the engineer to form a perception of its quality and (2) perceived to be of sufficiently high quality. Information from an engineer's personal files is accessible in a way that enables the engineer to assess its quality based on first-hand experience, and information from a longstanding colleague is accessible as trusted opinion. It is much more difficult for an engineer to form a perception of the quality of an external information source he has not used before. Determining the quality of an information source is essentially a matter of establishing to what extent one is willing to place trust in it, and this can be done with greater ease and precision for familiar sources. This challenges the principle of least effort by offering an alternative explanation of engineers' preference for close-by, internal information sources.

To investigate what engineers rely on in their assessment and choice of information sources, a longitudinal field study has been carried out. An analysis of the

meetings in the studied software design project shows that in discussing, selecting, and referring to information sources the involved software engineers devote significantly more attention to quality-related factors such as whether the source has appropriate project experience than to cost-related factors. This suggests that the software engineers are more in need of clarification regarding the quality of their information sources than regarding the cost of using them. The primary way of achieving this clarification is that someone in the project knows about the source and shares his/her personal opinion or some background information about the source with the other project participants. It is normal conversational practice at the meetings to accompany the mentioning of information sources who may be unknown to some project participants by information that put them in context. This way the software engineers share both hard facts and informal information that help them in assessing the trustworthiness of their sources.

Computer systems for managing knowledge and sharing expertise must recognise the rich means people employ in forming a perception of the trustworthiness of information sources and individual pieces of information. Either the information necessary to employ these means must be made part of the systems — if that is possible — or the systems must be made part of work practices that provide such context information. Otherwise the systems will end up disused, not because colleagues or other sources can be accessed at a lower cost but because the systems fail to honour the fundamental importance of trust in people's assessment and choice of their information sources.

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References

Allen, T. J. (1977). *Managing the flow of technology: Technology transfer and the dissemination of technological information within the R&D organization.* Cambridge, MA: MIT Press.

Bichteler, J., & Ward, D. (1989). Information-seeking behavior of geoscientists. *Special Libraries, 79* (3), 169–178.

Bishop, A. P. (1994). The role of computer networks in aerospace engineering. *Library Trends, 42* (4), 694–729.

Chakrabarti, A. K., Feineman, S., & Fuentevilla, W. (1983). Characteristics of sources, channels, and contents for scientific and technical information systems in industrial R&D. *IEEE Transactions on Engineering Management, 30* (2), 83–88.

Gerstberger, P. G., & Allen, T. J. (1968). Criteria used by research and development engineers in the selection of an information source. *Journal of Applied Psychology, 52* (4), 272–279.

Hertzum, M. (1999). Six roles of documents in professionals' work. In S. Bødker, M. Kyng, & K. Schmidt

(Eds.), *ECSCW'99: Proceedings of the Sixth European Conference on Computer Supported Cooperative Work* (pp. 41–60). Dordrecht: Kluwer.

Hertzum, M., & Pejtersen, A. M. (2000). The information-seeking practices of engineers: Searching for documents as well as for people. *Information Processing and Management, 36* (5), 761–778.

Kidd, A. (1994). The marks are on the knowledge worker. In *CHI'94: Proceedings of the ACM Conference on Human Factors in Computing Systems* (pp. 186–191). New York: ACM Press.

King, D. W., Casto, J., & Jones, H. (1994). *Communication by engineers: A literature review of engineers' information needs, seeking processes, and use.* Washington, DC: Council on Library Resources.

Mintzberg, H. (1975). The manager's job: Folklore and fact. *Harvard Business Review, 53* (4), 49–61.

Moenaert, R. K., Deschoolmeester, D., De Meyer, A., & Souder, W. E. (1992). Information styles of marketing and R&D personnel during technological product innovation projects. *R&D Management, 22* (1), 21–39.

Nochur, K. S., & Allen, T. J. (1992). Do nominated boundary spanners become effective technological gatekeepers? *IEEE Transactions on Engineering Management, 39* (3), 265–269.

Orr, R. H. (1970). The scientist as an information processor: A conceptual model illustrated with data on variables related to library utilization. In C. E. Nelson, & D. K. Pollock (Eds.), *Communication Among Scientists and Engineers* (pp. 143–189). Lexington, MA: Heath Lexington Books.

Pinelli, T. E., Bishop, A. P., Barclay, R. O., & Kennedy, J. M. (1993). The information-seeking behavior of engineers. In A. Kent, & C. M. Hall (Eds.), *Encyclopedia of Library and Information Science* (Vol. 52, pp. 167–201). New York: Marcel Dekker.

Rosenberg, V. (1967). Factors affecting the preferences of industrial personnel for information gathering methods. *Information Storage and Retrieval, 3*, 119–127.

Shuchman, H. L. (1982). Information technology and the technologist: A report on a national study of American engineers. *International Forum on Information and Documentation, 7* (1), 3–8.

Siemieniuch, C. E., & Sinclair, M. A. (1999). Organizational aspects of knowledge lifecycle management in manufacturing. *International Journal of Human–Computer Studies, 51* (3), 517–547.

Symon, G., Long, K., & Ellis, J. (1996). The coordination of work activities: Cooperation and conflict in a hospital context. *Computer Supported Cooperative Work (CSCW), 5* (1), 1–31.

Tseng, S., & Fogg, B. J. (1999). Credibility and computing technology. *Communications of the ACM, 42* (5), 39–44.

Valley, K. L., Moag, J., & Bazerman, M. H. (1998). "A matter of trust": Effects of communication on the efficiency and distribution of outcomes. *Journal of Economic Behavior and Organization, 34*, 211–238.

Van House, N. A., Butler, M. H., & Schiff, L. R. (1998). Cooperative knowledge work and practices of trust: Sharing environmental planning data sets. In S. Poltrock, & J. Grudin (Eds.), *CSCW'98: Proceedings of the ACM Conference on Computer Supported Cooperative Work* (pp. 335–343). New York: ACM Press.

Von Seggern, M., & Jourdain, J. M. (1996). Technical communications in engineering and science: The practices within a government defense laboratory. *Special Libraries, 87* (2), 98–119.

Zipf, G. K. (1949). *Human behavior and the principle of least effort.* Cambridge, MA: Addison-Wesley.

Zucker, L. G., Darby, M. R., Brewer, M. B., & Peng, Y. (1996). Collaboration structure and information dilemmas in biotechnology: Organizational boundaries as trust production. In R. M. Kramer, & T. R. Tyler (Eds.), *Trust in Organizations: Frontiers of Theory and Research* (pp. 90–113). Thousand Oaks, CA: Sage.