In Want of Information: A Case Study of Engineers in the South Pacific[1]

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ABSTRACT *This paper is primarily concerned with information networks and their significance to the development of technological knowledge in Pacific Island engineers. Essentially, the paper addresses a research agenda outlined by Cooper, who argues that studies of innovation in industrialised countries have relevance to technological capability development in developing countries. More specifically, the paper picks up on the theme of 'technological knowledge development as a communication process' where studies reveal the contribution that communication linkages within and between organisations make towards the development of this form of knowledge. Using Macdonald's 'information perspective' as an analytical tool, the paper identifies a number of organisational-related factors which constrain the access that these engineers have to problem-solving information. The paper argues that the organisation, and the social milieu in which it interacts, is influential in determining access to problem-solving information. This analysis provides support for Cooper's arguments and points to a broader set of challenges than is often accepted in development commentaries: that is, of information being widely available and easy to transport by communication technologies.*

Keywords: technological knowledge, development, information networks, learning.

Introduction

This paper begins by recounting the crisis surrounding the failure of a transmitter in a radio station in the South Pacific region. Normally used only for school broadcasts, the crisis was precipitated by both the impending parliamentary session, which required this transmitter to carry the supplementary English translation of parliament, and the recalcitrance of the transmitter in not yielding to the problem-solving efforts of the engineers. Because parliamentary broadcasts are popular with the general public, the failure of the transmitter represented a potentially embarrassing problem for the engineers and management.

A measure of the difficulties that the engineers experienced in resolving the problem was evident in the need for them to work throughout the night prior to the day in which parliamentary sessions began. The manager, after being assured earlier in the day that the problem was under control, was concerned to note when leaving the station later that night, the lights in the transmitter building ablaze and a number of vehicles parked outside, some of which were notably from the local telecommunications company. Following the trouble-shooting directions in the manual, the chief engineer told me that they initially checked the fuses supplying the RF Drive circuitry. From there, their efforts

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> centred on the RF Drive circuitry itself. All indications suggested that the RF Drive circuitry was in tact and the power supply was at fault. As no voltage measurements could be taken directly from the supply (because of its lethal potential), investigation centred on taking resistance measurements.
>
> Success was finally achieved when a chance discovery was made in which the fuses were disconnected from the circuit and tested once again. It was found that one fuse had in fact blown. As a spare fuse was on hand this diagnosis was confirmed and the transmitter was brought back into operation only a few hours before Parliament began. With hindsight, it was concluded that the large capacitors connected to the fuse contributed to providing a false meter reading, which led the chief engineer to initially determine that the fuse was in tact and to deviate on a time-consuming detour.

The story depicts a problem-solving situation of engineers working with a globally established technology—broadcast transmitters. The nightmarish experiences of the participants, reflected in the descriptions, belies the apparently simple solution of a blown fuse. The means by which these engineers acquire the technological knowledge they need to effectively manage the machines and equipment of modern technology represents an ongoing and important area of development research.[2] Cooper argues that the problem-solving processes that go to make up the experience of learning in developing countries, such as those related in the vignette, have much in common with the learning described in studies of innovation in industrialised countries.[3] He proposes a research agenda which looks to these studies for guidance in understanding barriers to learning within organisations of developing countries.

Cooper's research agenda is reflected in this paper in two ways. Firstly, and of primary significance, is the emphasis given to the social and physical environment in explaining the various paths taken by organisations in the learning of their technological capabilities, as exemplified by the concept of national systems-of-innovation.[4] In short, organisations, as living social units, have unique histories which influence the nature and direction of current and future knowledge development. Secondly, Macdonald's information perspective is used as a guiding heuristic to interpret the case study accounts.[5] Implicit to Macdonald's understanding of innovation is the idea of information being an unusual economic good, the value of which is difficult to determine. Information networks represent the means by which people are able to cope with these peculiar characteristics. How organisations respond to these characteristics is viewed as having important implications for the ways in which individuals solve problems and learn.

This paper explores the theme of technological knowledge development and the role of communication in this process. The literature identifies both experientially derived tacit knowledge and active networks of interpersonal communication as essential, though often neglected ingredients in the development of technological knowledge in engineers.[6] The introductory story serves to focus our attention on the first of these two themes by noting that the need to remove the fuse before testing was not clearly articulated in the manual, nor was it reflected in the actions of the chief engineer—that is until he discovered the need to remove the fuse. The presence of engineers from another department hints at the second theme of communication. Curiously absent from the account is contact with the transmitter manufacturer.

In line with a national systems-of-innovation approach, the themes of 'smallness' and 'isolation' are identified as dominant in shaping the individualised nature of organisations in the Pacific region. While these organisations are ostensibly created to counter the

particular manifestations of smallness and isolation within their local environments, the organisation of this study is argued to constrain, in more subtle ways, access to problem-solving information. Using Macdonald's information-based framework, this is demonstrated through scrutiny of the information transaction which reveals material and non-material costs in the acquisition of information.

Implications flowing from this paper relate to the limited set of parameters considered important in current development strategies. This issue is briefly considered with reference to a recently issued policy document from the South Pacific Forum on communications.[7] It will be argued that policy debate would be enhanced if more attention was given to the characteristics of information, and, more particularly, to the organisation's ability to cope with these characteristics and thereby improve the learning opportunities of its employees.

The research design is oriented to theory building through case study analysis.[8] The units of study are the engineering personnel, the organisation in which they work, and the machines and equipment that they manage. Data-gathering in the field comprised of participant observation, interviews and content analysis of documentary sources.

Technological Knowledge Development as a Communication Process

Cooper admits that a research agenda that links the learning efforts of practitioners in developing countries with those in high technology industries within industrialised countries may be problematic for those who associate innovation with the first time commercialisation of a new product.[9] While such a definition is in accord with the main thrust of Schumpeter's work, a source from which innovation studies draws much of their inspiration, Cooper points out that the learning process of imitation is a necessary precursor to innovation as well as being essential for the diffusion of new technologies. He contends that the meagre offerings devoted to this topic within the literature are not justified in view of its fundamental importance. Boulding suggests a more practical reason why an understanding of innovation must include imitation—as each of us grow older and must eventually die, there must be some means by which existing knowledge is carried over to the next generation.[10] Boulding describes the process as one of printing (rote learning) and organising (developing new knowledge). In any event, both authors identify imitation, as well as innovation, as being central to the question of development, including economic development.

From a historical perspective, the concept of imitation has proved to be far more problematic than originally envisioned just after World War II, when modernisation theories optimistically identified modern technology as a simple remedy to under-development. As Fransman explains, these earlier approaches viewed the importation of foreign technology in terms of a 'black box', where the most important capabilities were considered those embodied within the artefact.[11] The role of organisations and individuals was to quickly fall in line by applying these externally developed technologies. The realisation that the effective operation of these technologies was reliant on networks of complementarities which penetrated many areas of social and economic life, served to focus greater attention on capability development, particularly the process of knowledge diffusion and communication.[12] The difficulties of developing technological capability were encapsulated within Nelson's portrayal of the seller always possessing more knowledge of the technology's operation than could ever be provided to the buyer in blue prints, operating instructions and training.[13]

It was clear from Nelson's assessment that the partial success of the knowledge transfer process was attributable to the nature of this missing component of knowledge.

In contrast to that which was codified in books, drawings and instructions, (and floppy discs and web pages now), the missing knowledge component was less amenable to such codification as it was embedded in people's skills, and organisational routines. Referred to by Lamberton as a '... knowledge dichotomy ...'[14] definitions of technological knowledge have accordingly endeavoured to account for its two-part nature by distinguishing between its codified and tacit attributes, as seen in the definition that Turpin *et al.* employ:

> Codified knowledge is characterised by its embodiment in technological artefacts, literature, technological processes and the like. Tacit knowledge on the other hand, is embodied in people and their skills, technical know-how and experience in solving complex problems.[15]

Reasons why the tacit component remains unarticulated range from the difficulty in articulating all that there is to know, the limitations of language in describing relationships and things, or even perhaps, a lack of time.[16] Lamberton observes that when moving beyond this basic reasoning, '... explanations shade into communicative failure, which in turn shades into understanding and the information-handling capabilities of [individuals] ...'.[17] Hence, the tacit component of technological knowledge is seen as encapsulating a different set of communication problems than those which encompass the transfer of codified knowledge. The challenge lies in defining just what these problems are.

One approach which attempts to account for the communicative aspects of knowledge development, in spite of its uncertain attributes, is the study of knowledge sharing relationships between individuals within and between organisations. For example, Bell and Pavitt use the existence of intra- and inter-organisation links as evidence of the learning potential of organisations and cite the absence of such linkages as leading to poor outcomes in the diffusion of technology.[18] Antonelli attempts to better define the different forms of information flows which contribute to learning within the innovative organisation by describing two dominant modes.[19] He equates the commonly accepted model of knowledge transfer described by Arrow in the early 1960s as a '... top down process of deduction from known principles ...'.[20] In contrast to this, he observes that technological knowledge development is also informed by the localised learning-by-doing of experience as well as communication with other workers, customers and suppliers. Antonelli characterises this mode of learning as a '... bottom-up systematic process of induction from actual experience and communication ...'.[21] In summary, the intention is to capture the socially constituted and dynamic nature of knowledge creation and diffusion. In doing so, problem solving within the organisation is promoted as a legitimate knowledge creating activity.

Associations between technological knowledge development and communication are also found in empirical studies of engineers and technicians, the occupational group at the centre of this study. These studies indicate that the necessity for communication between practitioners is derived from the unknown characteristics of machines and equipment. For example, Staudenmaier asserts:

> [no] technology is ever completely understood, even after it has been introduced into normal practice. Technological knowledge is only a partial understanding of the characteristics of the real-life artefacts and processes.[22]

On the basis of his study of contributions to the science and technology journal, *Technology and Culture*, Staudenmaier argues that two bodies of technological knowledge exist to mediate the resolution of machine problems—theory and technical skill.[23] He characterises theory as having no direct association with problems which occur with

artefacts in the field.[24] Rather, he ascribes theory with the purpose of describing new concepts and defining particular attributes of problematic data. Technical skill, on the other hand, represents a form of knowledge which is distinct from theory in that it is derived from the experience of dealing with actual problems in the field.[25] Interestingly, Staudenmaier characterises theory as akin to a language.[26] Within this framework, the primary goal of technical schools and journals is to foster the learning of such language so that communication among practitioners about problematic data can take place.

This focus on the localised nature of problem solving is echoed by Forsythe who argues that theoretical knowledge is not self-evident but needs to be interpreted locally to achieve meaning.[27] Forsythe describes the engineers of her study as belonging to a particular cultural group on the basis that '... [t]he values and beliefs shared within a group constitute part of what anthropologists call culture ...'.[28] Forsythe asserts that culture defines what we take for granted and identifies '... tacit values and assumptions ... , and the common sense truths that everybody knows within a given setting ...' as underlying the comprehension of formal truths in theoretical knowledge.[29] The identification of culture by Forsythe portrays engineering as a pursuit influenced by the same uncertainties as other areas of social activity in which communication plays an instrumental role.

In drawing similar conclusions to Forsythe, Orr's study of photocopy technicians is particularly relevant here as it deals with technicians working some distance from the technological frontier.[30] Orr describes the photocopy technicians of his study as belonging to a '... community of technicians ...' and is effective in revealing the importance of interpersonal communication in ensuring that this community is able to collectively respond to the uncertain nature of photocopy machines.[31] It was found that there are many 'yet-to-be' discovered truths about the machine even though these practitioners have access to a full set of documentation and trouble-shooting procedures.[32] In contrast to the organisation's belief that the trouble-shooting procedures are incisive in resolving problems, Orr argues that experiential knowledge development and communication through story telling is at the heart of these technicians' capabilities.

These studies provide a number of windows on the development of technological knowledge in engineers which reveal communication playing an instrumental role in the resolution of machine problems. In promoting a more functional and distinct role for knowledge derived from experience, the need for interpersonal communication emerges as an efficient means by which this knowledge can be transferred. Supporting Cooper's arguments outlined earlier, the localised nature of knowledge creation identifies the organisation as an influential force in directing the learning efforts of its employees. An interesting point from Orr's study is the finding that the organisation may be ignorant of its function in promoting learning.[33] Curiously, the organisation viewed the fault direction documentation that it provided as being essential to the technician's work, while in reality the organisation's most notable accomplishment was enabling the technicians to work freely and communicate in a co-operative manner.

Capability Development in the Pacific

A national systems-of-innovation approach to development in the Pacific region looks to the dominant factors in the social and physical environment for explanations of how organisations have evolved. Commentators familiar with the circumstances of the Pacific region point to the themes of 'smallness' and 'isolation' as important concepts to explain why the economies and organisations of the Pacific are unlike those operating in industrialised countries.[34] Despite the availability of cheap labour, the realities of isolation

and smallness combine in the Pacific region to create an environment unsuited to initiatives that rely on large volumes of resource inputs, economies of scale and activities requiring large groups of individuals with specialised knowledge. The quintessential Pacific organisation is arguably one characterised by its isolation and small number of staff, as is the case with the organisation that this paper focuses on. At the time of this research, the radio station employed only 22 staff.

In view of the earlier findings, which identified experiential knowledge development and interpersonal communication as essential requirements for the development of technological knowledge in engineers, smallness and isolation represent a double-edged sword. Smallness implies insufficient numbers of experienced practitioners by which to gain the necessary economies of scale for problem solving and, by implication, knowledge creation. In the organisation of this case study, there are only four members in the engineering section, the chief engineer being the only member qualified to a sufficient and recognised standard for the role he performs. Conversations with the chief engineer reveal that he misses the input that a knowledgeable other might provide in the resolution of equipment faults.

> ... I can't rely on those other guys to help me—I have no one to discuss difficult faults with ...

Relationships with engineering staff in other organisations represent another means by which these networks of communication may be formed. The presence of employees from the telecommunications department detailed in the introductory account, though not officially sanctioned by either department, provides a further indication of the chief engineer's need for contact with other experienced practitioners.

While contact with engineers from other organisations is viewed here as a positive indication of learning potential, it must also be noted that the practical expertise which these employees from the telecommunications company provide is of limited relevance to radio broadcasting. The distances that separate these engineers from overseas equipment distributors, identified earlier by Nelson as a singularly important source of information, arguably represent a major impediment to learning. This brings into focus telecommunication technologies as the means by which these engineers are able to communicate with experienced broadcast practitioners in overseas organisations.

However, there is reason to believe that there is more to establishing these links between engineers than just providing them with a telephone or fax connection. Higgins notes that such are the perceived difficulties with isolation, skilled practitioners are still reluctant to shift into the Pacific region.[35] This view is given further credence by returning to the introductory account and noting that both the phone and fax numbers for a 24-h technical service hotline from the transmitter manufacturer were available for the chief engineer to use. Why the chief engineer did not avail himself of this service is perplexing, as he had access to both an international telephone and a fax machine (which is in the manager's office). In effect, what this example represents is the failure of what is conventionally regarded as the answer to the difficulties of isolation and smallness—the provision of a telecommunication technology and the phone numbers of the information sources.

An Information Perspective on Problem Solving in the Organisation

Macdonald's insights into the role of information in innovation are intended as an analytical tool by which to interpret the case study accounts.[36] Referred to in this paper as the 'information perspective', Macdonald's work can be seen as part of a broader area of information-related research that is distinguished by its desire to identify attributes of information which are of economic and social significance.[37] Macdonald's perspectives

on information is underpinned by the notion that information has unusual economic characteristics and the skills that individuals and organisations develop in coping with these characteristics have implications for the ways in which they learn. In short, Macdonald argues that difficulties in establishing common perceptions about the value of information between the seeker and supplier lead him to identify the 'information transaction' as a necessary element in the transfer of problem-solving information.[38] Information networks emerge from his analysis as a means to facilitate both the transaction and the transfer.

How Does One Get to Know What 'Everybody' Knows?

Macdonald makes the simple point that the existence of information at any location is explained by one of two reasons: the information was either transferred to this point or it was created there.[39] The introductory story demonstrates instances of both scenarios: a full set of equipment manuals and a chief engineer with the necessary formal qualifications are examples of information having been transferred to the radio station embodied within documentary sources and human beings; the later scenario is depicted in the discovery that the fuse required removal before testing. Also apparent is that the latter method, that is 'learning by doing', can represent a slow and uncertain process. That the discovery of this piece of information was the key to resolving the problem gives it special status within an information perspective, for without this piece of information, the transmitter would not have been repaired on time and this would have precipitated a crisis for the organisation.

The incident is even more interesting as the practice of removing components before testing is readily appreciated by experienced practitioners because of the falsifying effects other connected components can have on test readings. So, besides being a time-consuming process, the discovery is also an example of 'reinventing the wheel'. Why this piece of information had not made the journey to the radio station before this is therefore curious. The equipment manuals do not include this advice, but then the authors may also point to the disclaimer in the manual's introduction stating that the equipment should be worked upon by qualified personnel. Perhaps then we should look to the chief engineer's educational institution for not imparting this vital piece of information, though we should not discount the possibility that he may also have forgotten. If one defines tacit knowledge as that knowledge which has not been articulated, it appears that the information in question (prior to its discovery) satisfies this definition; and, if this information represents, as Forsythe describes, '... common sense truths that everybody knows ...',[40] how does one come to know the information that 'everybody' knows?

The response that Macdonald's rationale makes to this question is to highlight the chief engineer's difficulty in expressing demand for information which he is unable to define.[41] This is similarly described by Staudenmaier who cites technical problems as calling attention to an area of ignorance where one is not necessarily able to formulate a question.[42] Information networks play a crucial role in responding to this problem of the information seeker.[43] The more focused the areas of common interest are among members of the network, the more likely others will have an understanding of the information that others may need.[44] From this standpoint, the limited participation these engineers have in networks with experienced others represents a serious problem in gaining information that may be difficult to describe or articulate.

Macdonald draws a number of distinctions between what he describes as formal and informal networks.[45] Formal or institutional information networks are circumscribed within the organisation as official channels designed to ensure that information is

distributed efficiently to designated people on a 'need-to-know' basis. However, Macdonald contends that people have difficulty in distinguishing personal from organisational information and as a consequence, formal networks can be subverted, or complemented, by informal networks based on personal relationships.[46] Both informal and formal information networks work to facilitate the information transaction by ensuring, to varying degrees, that information of some mutuality is available to members of the network, thereby reducing the search costs to the information seeker. Significantly, informal information networks are viewed as being best for transferring 'difficult-to-get' information or tacit information.[47] This is because one's understanding of what constitutes another's information requirements is enhanced through the knowledge that comes from personal engagement with these people.

This leads to the argument that transferring information derived from tacit knowledge is dependent on a human element which stands apart from the actual channel, be it a telephone, fax, e-mail or face-to-face conversation.[48] By distinguishing between the codified and tacit aspects of technological knowledge there is justification in identifying communication that is more of an informal or interpersonal nature as being better suited to information which is difficult to articulate. So, while the concepts of information transfer and telecommunication networks appear to be obvious responses to knowledge development in the Pacific region, the account suggests that we should begin to discriminate within information characteristics based on the codified and tacit dimensions of technological knowledge. On that basis, our understanding of what constitutes a communication network may need to be reassessed. While it may be obvious to state that without a telephone line there can be no information transfer, it can be equally claimed that the absence of elements such as common interest or the understanding which comes through personal relationships will also constrain the transfer of information.

The Organisation's Role in Facilitating Information Access

In assessing the role the radio station plays in facilitating the provision of problem-solving information to its engineers, it is recognised that it has been instrumental in providing them with opportunities to receive education and training as well as supplying them with equipment manuals, tools and the like to assist them in carrying out tasks in the workplace. On the other hand, the following analysis from an information perspective suggests more subtle factors at play implicating the organisation in hindering the transfer of problem-solving information by constraining participation in information networks, formal or informal, with broadcast practitioners overseas. The analysis continues to focus on the concept of the information transaction. As well as the difficulties of the information seeker in demanding something he does not know, Macdonald contends that information transactions are needed to ensure that both the supplier and seeker of information establish an understanding of the costs and compensation before information transfer can take place.[49]

The issue of compensation for the supplier is based on the notion that information has value and that it can be appropriated by the individual who possesses this information.[50] In order for information transfer to occur, the supplier must be persuaded to part with this information. Macdonald contends that compensation for the supplier of information within the formal information networks of the organisation is by way of payment through wages or salary (though other motivations such as enthusiasm for work may also compensate the individual). Compensation for the supplier of information in informal networks is likely to be qualitatively different. The emphasis on trust and friendships in informal information networks gives the supplier some confidence that

compensation will come by drawing on the knowledge of others in the future—that is, by payment in kind. Macdonald further observes that those found not contributing to the network are, over time, dropped. Participation in informal information networks is thus one of giving as well as receiving.

Implicit in the information transaction is, therefore, the reckoning of costs that the information seeker must pay and the likely compensation that the supplier will receive. An analysis of the information transactions within the case study reveals that factors peculiar to the organisation and the broader institutional setting in which the organisation operates are influential in determining the access that these engineers have to problem-solving information. The analysis firstly looks to the broader difficulties that the radio station has in procuring tangible goods and cites this as an indicator of a more intrinsic problem in gaining access to intangible problem-solving information. Then the introductory account is revisited and the question is posed: why did the engineers not call the manufacturer for advice during the crisis? It will be argued here that non-material costs in acquiring information deterred the engineers from seeking assistance from overseas equipment suppliers.

At the time of the research, the radio station was required to channel all purchases through a central purchasing authority of the government. Ostensibly, the organisation did not engage in any direct contact with the supplier beyond obtaining initial quotations. It was necessary for these commercial transactions to be conducted across the legal jurisdictions of both the purchaser and the supplier. Extra safeguards were required to ensure that reciprocal obligations were met. For example, the central purchasing authority required all original documentation to be exchanged using the post which incurred significant delays. Additionally, suppliers usually required payment to be made before goods were despatched. Consequently, delays of 5–6 weeks or more between initial ordering and final delivery were not uncommon. This has had the effect of embarrassing the chief engineer when he made contact with these suppliers.

> ... I hate calling up overseas suppliers to ask for prices when I can't promise them they will be paid quickly ...

The protracted nature of these transactions often required the engineers to inquire with the supplier and the purchasing authority about the status of the order. When communication with the supplier did occur, it was dominated by the need to establish whether documentation or payments had been received and, if the goods had been despatched, their whereabouts in transit. The net effect for the chief engineer has been to prompt him to channel what orders he can through a local business even though the main area of expertise of this establishment is in telecommunications. This relationship is more friendly and conducive to the purchase of goods as the local supplier is willing to bear some of the risk by using his established line of credit with his suppliers, as well as extending credit to the central purchasing authority.

However, from an information perspective, the reduction in contact with overseas distributors represents lost opportunities for more productive information sharing relationships. While the requirement of common interest represents one ingredient necessary for information networks to function, issues of trust and compensation emerge as being important as they are also necessary for information transfer to occur but are nonetheless difficult to sustain over these large distances. Using the distinctions that Macdonald employs between formal and informal networks, it can be seen that the engineers have difficulty in compensating the supplier for any information they may be able to provide under either scenario. It is unlikely that the engineers will be considered a rich source of information to the supplier, at least as far as knowledge of the products in question

is concerned, thereby raising doubts about the value of payment in kind. In addition to this, thoughts of future commercial benefit, shaped by perceptions of the limited financial means of the radio station, represent another reason why problem-solving information may be difficult to elicit from equipment suppliers.

Interviews with engineers in other broadcasting organisations in the region suggest that they have similar experiences. For example, the former technical coordinator of the regional broadcasting body, the Pacific Island Broadcasting Association (PIBA), revealed that he has difficulty in acquiring the most basic of information from companies. His requests for quotations are often left unanswered which is even more unusual as he has funds to back these requests up with purchases.

> ... I have money to spend but I have to beg them to send me prices ...

As equipment suppliers are identified as a primary source of knowledge for these engineers it follows that difficulties in establishing commercial transactions with these suppliers have implications for the establishment of relationships of trust conducive to the transfer of 'difficult-to-get' tacit information. Therefore, it can be asserted that the institutional relationships linking the organisation to the purchasing authority and, in turn, to the overseas equipment supplier, work against the establishment of viable networks of communication with sources of potentially rich problem-solving information. While the bureaucratic procedures have arguably been instituted to counter the problems of isolation and smallness, on closer analysis they are found to compound the effect of these constraints by presenting more intrinsic barriers to the transfer of information. Also implicated are overseas equipment suppliers, whose perceptions, whether based on commercial acumen or ignorance, are also influential in determining the access that these engineers have to problem-solving information. Clearly, there are factors quite apart from the competency of individuals that are responsible for shaping the information sharing relationships that the radio station has with overseas equipment suppliers.

The difficulties in establishing viable commercial relationships could lead one to cite the reluctance of the engineer to contact the manufacturer during the crisis with the broken transmitter as a further example of the difficulties in gaining access to problem-solving information. As the transmitter had originally been purchased as part of an aid package, it could be argued that there is little commercial impetus for the manufacturer to assist the recipients of this aid. However, subsequent interviews with the transmitter's distributor in Australia cast a significantly different light on the matter and led me to discount the manufacturer as a significant factor preventing information transfer in this instance. While the distributor readily admitted that they were motivated by commercial concerns, they stated that the cost of providing the 24-h help service had been accounted for in the purchase price of the transmitter. In terms of providing compensation to the supplier of information, this cost had been paid in full in advance by the aid donor.

In analysing other possible reasons why the opportunity to consult the technical service was not used, issues of material and non-material costs to the organisation and the engineers were considered. Shyness was considered as one possible reason, though the chief engineer is quite proficient in English and is able to develop a good rapport with people, both local and expatriates. The high cost of telephone calls also figured prominently in consideration. However, there appears to be more intrinsic matters related to the non-material costs in acquiring this information, namely, his personal standing among his colleagues in the organisation, as well as the general community, which appear to dissuade him from seeking assistance from the manufacturer. In order to appreciate this more fully it is necessary to try and view the situation as best we can from the participants' stand point.

The failure of a radio broadcast transmitter is a very public event and the small size of the community doesn't allow the kind of anonymity one might enjoy living in a larger community. The technical complexities are compounded by the social demands made upon the organisation and, in turn, upon its engineers. Coupled to this appears to be a poor appreciation of the complexities of engineering. The manager commented:

> ... I don't understand the technical side as well as the ... [former manager] ... so I rely on the ... [chief engineer] ... to tell me what's going on. I sometimes feel he is hiding things from me and I don't know why ...

Staff training and development is largely conceived in terms of the theoretical knowledge gained from education and training where the attainment of formal qualification confers one with an ability to solve problems, even if one has just emerged from training. Families celebrate the educational achievements of their children where qualifications are seen as the basis for added standing in the community. While studies such as Orr's suggest that advice seeking is not only normal but necessary for technicians, within the context of this organisation needing outside assistance is likely to be perceived as an admission of being unable to single-handedly resolve the problem. This contention is supported by the manager's surprise at noting the frenetic activity late at night after being given solid assurances earlier in the day that the transmitter would be repaired in time.

In this context, contacting the manufacturer for advice, even late at night, does not represent an attractive option as the high cost of international telephone calls ensures that the itemised telephone bills are scrutinised closely by the accounts staff and the manager. While the status of the technical help service as a formal or informal arrangement is not wholly clear, the lack of organisational scrutiny Macdonald describes as being required for informal networks to flourish would clearly be of benefit to the chief engineer here. This example suggests that the behaviour of individuals is once again being shaped by the contingent circumstances of the organisation and the community rather than by a lack of individual proficiency.

In summary, an information-based analysis of the case study identifies the organisation as influential in determining access to problem-solving information. The limited involvement of the engineer in interpersonal communication networks with other broadcast engineers represents an area of significant concern for the case study participants in gaining access to the knowledge of more experienced practitioners. While the high cost of telephone calls represents one obvious factor constraining the formation of such networks, it was found that factors more intrinsic to the nature of the organisation were also of significant influence. The difficulties the organisation has in maintaining viable commercial relationships over distance was argued to be a poor basis on which to build relationships of trust, commercial or personal, necessary for the transfer of information. Furthermore, a disproportionate emphasis on codified knowledge development over tacit knowledge development was found to influence the behaviour of the engineers in ways which detracted from their effectiveness in solving problems. The costs of seeking assistance from outside the organisation in terms of personal standing with organisational colleagues are plausible deterrents to the formation of relationships with outside agents, despite considerable evidence to suggest that such links are necessary for these engineers, particularly in the early stages of their careers. The processes by which these individuals learn are hence found to be markedly influenced by specific attributes of the organisation and its relationship to the broader social setting.

Wider Implications for Theory and Policy

Returning to Cooper's original proposal for a development research agenda informed by the studies of innovation, it is evident that the application of Macdonald's information-based rationale to this case study material yields insights into the effect that organisational dynamics have on problem solving.[51] While it is acknowledged that the organisation represents the primary means by which these practitioners are able to gain access to learning opportunities through education, training and in the workplace, it is apparent that some aspects of the organisation's functioning have detracted from the development of the technological capability in these engineers, particularly as it relates to tacit knowledge development.

The paper therefore points to a broader set of challenges than is often granted within policy-making frameworks. One notable example can be found in a recently issued policy document on communications by the South Pacific Forum.[52] The document responds to the growing popularity of the concept of a Global Information Infrastructure (GII) in which a vision for the Pacific Information Economy is described in terms of '... enabling all citizens to take part in the opportunities brought home by the global information economy ...'.[53] However, most of the document's subject material is devoted to liberalising the regulatory environment of the Pacific region to facilitate open competition between (private) telecommunication operators. Topics such as inter-operability, telephone numbering and unbundling of services are representative of those under scrutiny. While recognising the fundamental informational deficiency problem of the Pacific, the document spends little time drawing definable links between the liberalisation of Pacific telecommunication markets and the value adding processes that the vision for an information economy implies.

The insights delivered by this paper suggest that greater attention to the ways in which the characteristics of information and the organisation interact is warranted. More specifically, the paper identifies the following questions as important.

- *What special measures are being considered to account for codified-tacit knowledge dichotomy?* While it is accepted that on-line technologies are eminently suited to the transfer of codified information, the communication of choice for the interactive nature of tacit knowledge appears to be face-to-face communication, and if this is not possible, voice communication or e-mail communication.[54] While e-mail is cheap, traditional voice communication is still horrendously expensive in the Pacific.[55]
- *To what extent are telecommunication providers concerned with the difficulty of accounting for the value of information to both the supplier and the end user?* While telecommunication carriers may be content to measure information by the formula of distance versus time versus bandwidth, this in no way accounts for the costs and value this information represents to the end user or the supplier. This paper identifies ways in which these factors are implicated in constraining information access and notably, not accounted for in this policy document.

Ultimately, it appears that the issue for communication policy makers is that any proffered 'telecommunications' solution will always be one step removed from where the action is—the problem-solving activity occurring within organisations. In terms of the direction this paper provides to further inquiry, most significant is the need for a revision of how the concept of network is defined. While the tangible infrastructure of communication networks is by far the most dominant in current discourse, the concept of network espoused by this paper is one which attempts to capture the intangible nature of networks, such as relationships between individuals or organisations, common interest

and trust, and view these attributes as being necessary to cope with the unusual characteristics of information. Macdonald suggests that if telecommunication policy makers are serious about achieving a more fundamental capability with what the end user is trying to do, their understanding of network needs to accommodate the uncertainties of dealing with the intrinsic value of information and the need for information transactions which enable information transfer.[56]

Conclusion

In conclusion, this paper was primarily concerned with identifying ways in which knowledge development in a group of Pacific Island engineers was facilitated or constrained by their organisation. By linking the interpersonal communication that occurs between engineering practitioners to the process of knowledge development, the paper identified ways in which the organisation constrained knowledge development by limiting the participation of its engineers in such communication relationships. These constraints were argued to be a manifestation of local responses to the two themes of smallness and isolation, giving support to the concept of national systems of innovation described by Cooper. The paper therefore endorses an approach which draws insights from innovation studies to better understand the process of capability development in less developed countries. In particular, the use of Macdonald's information-based framework crystallises the need for a definition of communication network which is centred on the end-user's difficulty in acquiring problem-solving information. Emphasis on the intangible aspects of active communication relationships maps out a telecommunications policy agenda which is broader than the current emphasis on the tangible infrastructure of communication technologies.

Notes and References

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