Knowledge Translation Capability and Public-Sector Innovation Processes

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Abstract

Public sector organisations are increasingly becoming aware of the need to harness the innovative capacity of their employees. In the UK many public sector research institutes have put in place processes to increase the speed at which new technological innovations are exploited and commercialised. These types of initiatives have also been implemented into public sector service organisations. For these service organisations innovations occur not just from formal research projects but are also practice based, developed by staff in the course of their normal work. This paper suggests that practice-based innovations can be seen as relying heavily on Mode 2 knowledge production. Using the UK's National Health Service as an example, the characteristics of practice-based innovations are characterised as tightly coupled to their development context and combining hard and soft technologies. A model of knowledge translation capability is presented that supports Mode 2 knowledge production and is then used to analyse a case study of a practice based NHS innovation. Implications for NHS innovation policy are suggested and further areas of research into public a sector innovation processes outlined.

Introduction

Public sector organisations have a long history of involvement in technological innovation. In the UK, important technologies such as radar, liquid crystal displays and microwave ovens have all been developed initially within public sector research

establishments (PSRE). Within the health sector, teaching hospitals have played an important role in developing new health technologies. These innovations have generally stemmed from formal research projects and can be categorised as research-based innovations. It is only relatively recently that the importance technological innovations developed from operational parts of the public sector has been recognised. These innovations often result from ideas generated in the course of peoples' work and can be seen as practice-based innovations. These projects have a value to the UK's National Health Service (NHS) both in terms of enhancing patient care, and generation of income based on the exploitation and commercialisation of innovative technology. In the NHS there is now a recognition that support should be available for those developing practice-based innovation projects.

The organisational learning and knowledge management literature highlights that there are differences between how practice-based and research-based innovations occur. These differences are best described in the comparison of Mode 1 and Mode 2 knowledge production (Gibbons, Limoges et al. 1994; Nowotny, Scott et al. 2001; Nowotny, Scott et al. 2003). This paper suggests that many NHS innovation policy decisions are based on the implicit assumption that innovation occurs through Mode 1 knowledge production processes. Instead, it recommends that policy to support practice-based innovations demands the recognition of Mode 2 knowledge production processes.

An important process that underpins Mode 2 knowledge production is the effective use of knowledge held either outside the organisation or within existing parts of the organisation. This can be seen as a process of knowledge translation (Savory 2005) in which existing knowledge is applied in new ways and situations. The knowledge translation process can be seen as an organisational capability that potentially enhances organisation's ability to develop practice-based innovations.

The paper argues that innovation policy needs to take account of the needs of both hard and soft technologies (Swamidass and Nair 2004) and their coupling within systems of health technology. It then discusses how culture, structure and policy inter-relate to create the context in which NHS innovations occurs. A conceptual model of a technological competence is presented as a basis on which to understand the knowledge processes underpinning practice-based innovations. Several examples of how the processes operate are illustrated through the use of a recent case of practice-

based innovation. Several recommendations are made for improving innovation policies, in particular to take account of the need for the NHS to develop a knowledge translation capability.

Nature of NHS innovations

Innovation can be viewed as the process linking a creative invention to production of a product capable of adding value .The range of innovative activity possible in a large organisation such as the NHS is wide ranging and heterogeneous. Before discussing the organisational context in which innovation occurs, it is useful to examine the nature of innovation. First in terms of the kind of technology and the innovative activity that produces it. Second, in terms of the technology's market and potential users. This section discusses a way of classifying NHS innovations and their potential markets.

Classifying NHS Innovation

Technology can be defined as comprising specific physical artefacts; technical knowledge; and processes for enquiry and action in relation to technology (Custer 1995). This definition suggests a useful pair of categories of technology, hard technology based on technological artefacts and soft technologies based on technological knowledge or the process of enquiry that leads to the development of knowledge (Swamidass and Nair 2004).This distinction, originally made in a manufacturing context is also appropriate to healthcare technology. Within healthcare hard technologies can be seen as devices, drugs etc. while soft technologies are based on the procedures and practices used in patient care. Within the EU medical devices directive medical technology has been defined that encompasses mainly hard technologies; thus a hard healthcare technology can be seen as an:

"…instrument, apparatus, appliance, materials or other article, whether used alone of in combination, including the software necessary for its proper application intended by the manufacturer to be used for human beings for the purpose of:

- *diagnosis, prevention, monitoring, treatment or alleviation of disease*
- *diagnosis, monitoring, treatment, or alleviation of or compensation for an injury or handicap*

- *investigation, replacement or modification of the anatomy or of a physiological process*
- *control of conception"*

EU Medical Devices Directive (93/42/EC)

While some soft technologies may be free of any physical artefacts, for many soft technologies there will be one or more hard technologies embedded within; the hard technologies support and enable the use of a soft technology. Diffusion of technological innovations therefore depends upon implementation of a complex system of hard and soft technologies. This tension between hard and soft technologies is demonstrated in the case of a new ECG machine that was designed for use by non-specialist staff, based in GP surgeries rather than specialist cardiac departments (HITF 2004). A significant level of expert knowledge was embedded in the technology, allowing a radical redesign of the patient heart assessment process, this process essentially representing the soft technology of patient diagnosis.

Even for hard technologies that have encapsulated expert knowledge (as is the case of the ECG machine,) there is a still an overhead of training required in the soft technology allowing its use. The embedding of expert knowledge within a hard technology (Blackler 1995), does not imply that users of the technology are deskilled, but are likely to need re-skilling. Hard technologies impact on the skills required by users, "The more systematic surveys of automation's skill requirements … show that while the net effect of subtractions from, additions to and qualitative mutations of, the workers task set is most definitely not always positive, the general tend has been an upgrading, not a de-skilling. This is the most plausible interpretation for the data that shows both a secular shift in the occupational structure, which has given more weight to the more-skilled occupations, and an increase in the skill requirements for most individual jobs."(Adler 1986). The implication of this is that while hard technology can be developed to embed expert knowledge, the skills and processes that support its use will undergo a corresponding transformation to support its successful use.

The source and nature of NHS innovations can be characterised differently to those coming from purely commercial producers of health technology. In common with the view that scientists are the major source of innovation in scientific instruments, based on their superior understanding of the problems to be solved (Hippel 1988), NHS staff

are often well placed as the source of innovation of health technologies and can be viewed as sophisticated users of technology (Souder 1987). It is through the interaction of technology and its use that innovation proceeds (Howells 1997). The technological innovations produced by staff within the NHS, both hard and soft, are the product of the knowledge held by the NHS staff. While some hard technologies can be seen as highly generalised and aimed at solving generic problems, for example "what temperature is this patient?" Other hard technologies are developed to enable the use of very specific soft technologies. Innovation can occur either to allow an existing soft technology to be performed better, for example, keyhole surgery or a hard technology may allow radically new soft technology to be implemented.

Christensen has highlighted how innovation in soft healthcare technologies allow their operation by less specialised staff; this innovation itself is enabled by innovation of hard technologies (Christensen, Bohmer et al. 2000). He suggests that various disruptive innovation in health technologies leads to changes in the groups involved. In the case of diabetes care, patients were once unable to monitor precisely their glucose levels, without the aid of specialist staff. Since the development of glucose monitoring devices, patients are now able to not only take the reading but also then manage their diabetes themselves. This is an example of where the innovation of the hard technology has enabled the soft technology, patient managed glucose levels, to be developed. Christensen cites several examples ranging from open heart surgery requiring specialist surgeons to relatively simple procedures, such as diabetes management that have undergone such innovation. These innovations have lead to both changes in the required performance of hard technology and the user group concerned with implementing it. An important shift caused by these innovations is the change in user groups. He cites four main levels of use for health technology: medical specialists; primary care staff and GP's; nursing staff; and patients. For each of these levels of use the hard technologies are created to satisfy the wider needs of the soft technology operated by the user group. Thus, for medical specialists diagnostic devices are likely to be highly accurate, precise and provide a sophisticated user-interface; while for "self-care" situations the corresponding device is likely to have simple interface with minimal instrumentation. For each group of users both the hard and soft technologies employed will have distinct differences.

Dual market for innovative technologies

In common with other public-sector organisations that are both users and innovators of technology, such as the military, the potential for transferring innovations from their original development context is very great. Two potential markets exist, first internal technology transfer to other parts of the organisations, second to an external market. Based on the distinction between hard and soft technologies made above, several differences in the needs of these markets can be identified.

In the case of technology transfer to external markets there is a need to abstract technology out of its original context. The transfer is also likely to focus on mainly hard technology. This is because it is the hard technology that is most readily transferred and in particular its IP rights can be most easily protected. Thus in the case of a innovative surgical procedure, commercial exploitation is likely to focus on key hard technologies that support the procedure. This is because IP associated with hard technologies can be protected e.g. through patenting. In contrast it is not yet possible to patent a surgical procedure. The implication of this, for example in the case of a medical device manufacturer, the core product is the hard technology, the device itself. The customer will then implement the device into its own organisational context and practice. The soft technology associated with the device may also be implemented, however, this is by no means automatic as the customer's own organisational context may be very different to the original development context.

In contrast, technology transfer to an internal market has potential to be based primarily on the soft technology. In the case of an innovative procedure, the diffusion through the organisation may well focus on the replication of the process. This focuses both on the soft and hard technologies associated with the innovation. Technology transfer within an organisation may be more successful with respect to soft technology due to the common features across the organisation.

Soft technologies are highly coupled systems with hard technology embedded within them. Hard technologies in contrast are less coupled and have tighter boundaries.

The implication of this distinction between internal and external technology transfer is that the way an innovation is assessed will be affected by the perceived market. Innovations that yield hard technologies will most likely be seen as appropriate for external technology transfer. While innovative soft technologies, even with embedded hard technologies, will be seen as innovative processes or "best practise". Hard

technologies will tend to be the focus of external technology transfer efforts, due to the difficulty of commercially exploiting the soft technologies.

This section has suggested that NHS innovation is concerned with both hard and soft technology. The aim of the innovation process for many hard technologies is development of products for the global healthcare market; its main emphasis is external technology transfer. While for soft technologies, the innovation process is more complex, it must address the tightly coupled relationships that exist with hard technologies and manage internal technology transfer.

The NHS Innovation context

The following section analyses the context in which NHS innovation takes place. Three perspectives on the context are discussed based on the NHS's culture, structure and explicit innovation policy initiative.

Culture

The existence of an appropriate culture has been suggested as important to innovative organisations Many large organisations such as 3M, Microsoft and Hewlett Packard have their innovative cultures linked to charismatic and innovative leaders. These leaders have influenced values and practises supporting innovation over a long period (Deschamps 2003). The presence of an innovation culture may be a pre-requisite to encouraging technological innovation in the NHS. This raises the question of whether the NHS does have an innovative culture? Any attempt at characterising the culture of the NHS is prone to generalisations simply because of the size and diversity of the organisation. Several observations can, however, be made.

The primary base of power in the NHS is medical knowledge, and because of this doctors in particular hold significant power (Worthington 2004). Other healthcare professionals such as nurses and paramedics hold lower levels of power and influence. The powerful position of doctors leads to scientific method being the primary process for validating knowledge. This has implications for technological innovation as evaluation of technology tends to be based on a search for "scientific fact". This may be limiting as epistemologies based in the social sciences carry less credence (Jones 2001).Thus despite the need to recognise the socio-technical dimension of technology, NHS decision-making is underpinned by a knowledge

validation process based on a positivist epistemology. Though alternative epistemologies have been used in clinical settings (Reason and Bradbury 2000), they remain marginal. This strong positivist worldview is illustrated by a statement from a senior manager at the NHS Modernisation Agency when commenting on continuous improvement methodology applied to the NHS. They stated that "… data are presented in a format that is easily understood and *statistically valid, which appeals to doctors*…" [author's emphasis] (Rogers, Silvestor et al. 2004). It is revealing from this statement that in order to drive improvements to organisational rather than medical operations, NHS decision making requires scientific levels of proof. As increasingly recognised in the management literature, this may lead to a myopia in which only the measurable is managed, or even believed.

The cultural propensity for scientific knowledge leads to initiatives being led by scientific method. For example, the NHS has since the early 1990's placed emphasis on "evidence based clinical practice". This approach to clinical practice is concerned that where research data is available it should drive clinical practice. There have also been moves to develop "evidence based policy" in the NHS. Both these initiatives are an attempt to transfer scientifically validated knowledge into clinical practice and policy making. While there has been some criticism of evidence based policy on the grounds that research results are often too context specific to be widely generalised (Black 2001). Evidence based policy in the NHS has attracted specific criticism on the grounds that policy requires a more pluralist and diverse approach and to recognise that policy often requires compromises between competing view-points (Marmot 2004). Evidence based initiatives are an example of the predominantly positivist culture in the NHS rooted in the dominant views of the medical profession.

While emphasis on scientific knowledge and the division of the organisation on functional specialisms has allowed the enhancement of patient care through practitioners gaining specialist skills; innovation has been impeded by rigidity; pecking orders; strict demarcation; tribalisism between staff; and departmental silos (Rushmer, Kelly et al. 2004). While the source of many innovations may be the combination of diverse disciplines, the NHS's predominantly functionally based structure acts against such innovation.

The NHS has a strong culture of professional autonomy because of the NHS's structure primarily being based on functional specialisms (Worthington 2004). This structure should provide an effective setting for innovation work to occur, as professional staff has some control and discretion in how they approach their work. There are however a number of factors that may stop individuals pursuing certain innovations. There is increasing requirement for new practices to be rigorously tested prior to being approved by regulatory authorities at national and regional levels. This in itself carries with it a significant overhead that can potentially retard innovative activities. While there are parallels between the culture of hospitals and universities in terms of levels of professional autonomy, the main purpose the organisation is the delivery of patient care. The demand for such services is high and so for many staff there is little time to spend on innovative activities.

In order to develop a thriving innovation context in the NHS, account needs to be taken of its culture. As outlined above the NHS's culture is complex and heterogeneous; complex because of the web of power relationships; heterogeneous because of the diversity of disciplines and roles. In addition to its size the NHS also experiences a high rate of change. Significant change has been rooted in external pressures e.g. government initiatives. Perhaps the most acute driver of change is technology. The rate of technological change has implications for the organisation in terms of both resourcing new technology and the development of skills to use it. The past twenty years has seen a succession of initiatives in the NHS, this has resulted in "change fatigue" becoming endemic in staff. For these reasons, an approach to managing innovation in the NHS must be sensitive to the diverse cultures and recognise that for an organisation experiencing rapid change any "solutions" are likely to be only transitory.

Structure

Structural change in the NHS has been great over the past twenty years, and it is likely changes are to continue into the future. These changes however can also impact on innovation, either in encouraging or retarding it. Several recent examples of change are discussed below and their impact on technological innovation is highlighted.

The NHS is organised into strong functional specialisms, which are overlaid with strong professional roles. In turn these functions and roles have become institutionalised into a tight bureaucratic structure that supports and co-ordinates its activities. Since the 1980s there has been a gradual change in the role of professional managers in the NHS. Up until the 1980s the role of managers has been characterised as to support the work of professionals and nurses in carrying out their work. Their primary role was seen as ensuring that the necessary resources were available at the appropriate time (Worthington 2004). Only after the Griffiths inquiry of 1983 was the role of managers made more explicitly concerned with performance management or strategic change. This has led to an increased convergence between the areas managed by either medical professionals and management (Harrison and Wood 1999). While it would be wrong to suggest the autonomy of medical staff has been eradicated, NHS decision-making has an increasingly managerial emphasis. This can affect innovation, as in order to drive through projects, staff must be capable of providing both a technical rational and a clear business case for projects.

Up to the 1990s the NHS was organised as a single, large professional bureaucracy (Mintzberg 1993; Harrison and Wood 1999). Since then there have been a number of structural changes to its operation that have both enhanced and constrained potential for technological innovation. As part of the NHS and Community Care Act 1990 an internal market was formed within the NHS. This made an explicit split in the NHS between purchasers and providers of health services. During the 1990s, this was developed into a system of primary and secondary care trusts. Though the emphasis was on an internal market was abandoned, as it failed to integrate the NHS or promote widespread partnerships (Greener 2004), the system of trusts has continued to develop. Primary care trusts remain as commissioners of services from acute trusts. While the element of competition between trusts has been reduced, there is still a strong internal cost accounting structure. This has an impact on innovation as while service delivery crosses boundaries e.g. between primary and acute trusts, investment in new technology takes place at the trust level. This has an effect that where investment in innovative technology is born by a primary trust, the most significant impact on efficiency and effectiveness may be gained by acute trusts.

The centralised purchasing function that existed in the NHS before the 1990’s has continued to operate, though in a modified form. In 1991 the purchasing function was

reorganised as a special health authority called NHS Supplies. The aim of the authority was to achieve best value for money for the NHS. In April 2000 NHS Supplies was developed into the NHS Purchasing and Supply Agency (PASA), an executive agency of the Department of Health. PASA acts as a strategic advisor to the NHS on procurement. The agency oversees a complex supply chain to the NHS that includes pharmaceuticals, equipment and consumables. The impact of purchasing policy impacts on the diffusion of innovation into the NHS. While efforts are made to ensure that purchasing decisions are made at an appropriate level, the agency has a role in assessing individual products for use in the NHS PASA operate a list of approved products for use in the NHS. This list is based on providing value for money but has become a *de facto* standard for approval of products used in the NHS. Even for products based on innovations originating from the NHS, the acceptance of the product onto the PASA list is a major step in gaining widespread NHS use.

While PASA are concerned with the most effective approaches to purchasing technology used in the NHS, there has also been a move to ensure that health technologies used in the NHS are cost effective. The National Institute for Clinical Excellence (NICE) was set up in 1999 with the aim of national guidance on economic use of resources in relation to patient care. Initial criticism of NICE suggested that it did not assess new technologies in a completely objective manner and had "…effectively become an advocacy mechanism by which lobbies of specialists and their supporters in the pharmaceuticals industry…"(Cookson, McDaid et al. 2001). It is suggested that one of the main purposes of NICE is now to ration the use of health technologies in the NHS (Maynard, Bloor et al. 2004). This is based on the need for the NHS to contain spending on new technologies and balance effectiveness and cost. As such NICE are a primary gatekeeper for new technologies to the NHS and so now constitutes either a potential aid or barrier to innovation diffusion. Successful diffusion will be dependent on explicitly satisfying an object assessment of their performance NICE. However, success may also be dependent on gaining the backing of powerful groups of clinicians, patients or health industry organisations

Changes in the role of managers, creation of trusts and the development of agencies such as NICE and PASA are not the only changes that impact on NHS innovation. They do however demonstrate that the range of changes that are going on in the NHS

can, when combined, have unforeseen consequences for promoting or stopping innovative activity.

Policy

The organisational context in which innovation occurs in the NHS is strongly affected by policy. Like any public sector organisation, these policies are driven not just by the organisation itself but also the political forces of government. There have been a number of policy initiatives that have lead to change in the NHS, though not always with the specific aim of generating an innovative culture.

There have been a number of explicit efforts to improve the rate of innovation in the NHS. These can be seen as furthering one of two potential goals. The first goal has been to capture and protect commercially valuable intellectual property produced within the NHS, and then to exploit it though licensing or creation of spin-off companies. The second has been to operate a culture of process re-design and continuous improvement within the NHS, so that innovations developed in one part of the NHS are shared throughout the service. The aim of supporting and exploiting NHS innovations can be seen as either to produce healthcare products for the global healthcare market or in order to diffuse them within its own “internal market”.

The drive to protect and exploit IP produced within the NHS can be seen as part of a broader move to commercialise IP developed in all public sector research establishments (PSRE). Suggestions for improved flexibility in the management of R&D in the NHS was set out in the early 1990s. The Culyer report highlighted that R&D occurred throughout the NHS and not just in teaching hospitals and that R&D needed to be seen as a core activity (Culyer 1994). More broadly the Baker report set out a rational for why and how increased commercialisation of NHS R&D could occur (Baker 1999; Office of Science and Technology 2000). A number of other subsequent NHS specific initiatives were then made to better manage IP in the NHS (Culyer 1994; DoH 2002; DTI 2004; HITF 2004). The emphasis of these initiatives were on establishing a clear process for identifying, protecting and exploiting IP. The ultimate aim of these initiatives is to establish income streams from innovations originating in the NHS. This income could then be used to improve patient care

The move to generate innovation that either acts to re-design NHS processes or contribute to continuous improvement can be seen as part of a modernising agenda.

The general focus of this drive has been on the identification and promulgation of best practices. The NHS Modernisation Agency was proposed in 2000 to support change management, mirroring similar initiatives in the private sector (UK Government 2000). It had a role in promoting continuous improvement of services, but also to promote locally managed service re-design. The agency was not however charged with managing innovation in technologies such as medical devices.

The policies on NHS innovation were clearly demarcated between innovation of services and innovation of technology. There was no apparent recognition that the two are linked. This division was articulated in the DoH guidance in management of intellectual property in the NHS:

> *"An innovation can be used to improve the health service in one of two ways. First, after suitable evaluation, it could be freely disseminated across the NHS by knowledge management processes. Second, the evaluation may show that it is best treated as an invention… It may not be clear until after evaluation which path an innovation should follow. NHS bodies will need to have in place a management process to comply with Research Governance responsibilities, with an identified lead person able to respond professionally to employees. The formal audit process carried out by NHS bodies to review their R&D outputs, commonly called 'technology audit', may also identify IP that is a 'good practice' innovation which needs to be evaluated and disseminated freely when appropriate. Plans are being put in place to capture these innovations which have no commercial value but the potential to improve health and to save expenditure by the NHS."(DoH 2002)*

This two pronged approach to innovation resulted in service improvement becoming the preserve of the modernisation agency, while commercially valuable innovations were the preserve of a separate agency (Savory 2005). NHS Innovations, was responsible for overseeing the creation of a number of technology transfer offices, known as NHS innovations hubs (DoH 2002) to support the protection and commercialisation of NHS IP. Though in 2005 the two agencies were brought into the same body, the NHS Institute for Innovation and Improvement (NHS Institute for Innovation and Improvement 2005), the separation of service and technology innovation was maintained.

Culture, structure and policy act together to promote technological innovation in the NHS. Unfortunately, changes that are not explicitly linked to innovation initiatives can be either supporting or damaging to the innovative capability of the NHS. The section that follows proposes an integrated model that can be used to help understand the delicate balance of activities that support a healthy, innovative organisation.

Applying Mode 2 base innovation to the NHS

This section introduces a conceptual model of knowledge translation capability; a capability that underpins Mode 2 knowledge production. The model integrates relevant material from both the organisational learning and knowledge management literature.

The way in which the NHS handles its innovative technologies can be seen as part of two linked, high-level, conceptual issues. The first of these is the way the organisation itself acts to improve its own performance through organisational learning processes. This can be seen as a performance improvement capability. Second, the way in which it creates a conducive environment for its employees to absorb, modify and contextualise knowledge from one part of the organisation to another, or from outside to within. This can be seen as based on the absorptive capacity (Cohen and Levinthal 1990; Zahra and George 2002) and combinative capability (Kogut and Zander 1992) of the organisation. Only a limited insight into how best to manage the overall NHS innovation process can be gained from seeing innovation purely as a “technology push” (Howells 1997). This paper suggests that the capability to manage performance improvement through effective knowledge management can be described as a knowledge translation capability.

For healthcare organisations in particular, focus is now being placed on how they can improve their effectiveness and efficiency. Generic approaches to managing improvement have been introduced e.g TQM and continuous quality improvement processes. While these can address incremental innovation in individual hard and soft technologies, they do not actively address the problem of how practice-based innovations can be encouraged and supported, especially where such innovation can result in major service redesign. In particular the recognition that innovation processes supporting generation, implementation and diffusion of are all closely related. In the healthcare context suggestions have been made for a specific performance

improvement capability, based on the interaction of five components: skills, systems, structures, strategies and culture (Adler, Riley et al. 2003). Unfortunately, such a model provides little insight into how practice-based innovations that result in complex combinations of hard and soft technology can be best facilitated.

Practice-based innovations result from distinctly different processes of knowledge production to those derived from research-based activities. For innovations developed by individuals and teams in the course of their work, knowledge production can be characterised as Mode 2 (Gibbons, Limoges et al. 1994; Nowotny, Scott et al. 2001). In particular the features of practice-based innovations share closely the qualities of Mode 2 knowledge production: knowledge produced in the context of application; trans-disciplinarity; heterogeneity of sites in which knowledge is produced; social accountability; and reflexivity; and novel forms of quality control (Nowotny, Scott et al. 2003). The use of Mode 2 knowledge production as a conceptual model is particularly relevant to the NHS, especially as it is a context in which the commercialisation of research and globalisation trends are having significant impact. A knowledge translation capability that supports the development of practice-based innovations must therefore recognise these “Mode 2” characteristics. Nowotny *et al* suggest that Mode 2 knowledge production must be managed in new ways (Nowotny, Scott et al. 2003).

In the case of the NHS, technological innovation will depend on how effectively knowledge is transferred, combined and used in new situations. Boisot suggests a model of social learning that suggests three dimensions in which knowledge is transformed through: codification, abstraction and diffusion (Boisot 1998). These three transformations must occur for practice-based innovations to occur and so a model of knowledge translation capability must include appropriate processes to support the transformations. Boisot’s social learning model is particularly relevant to Mode 2 knowledge production as it emphasizes the transformation of knowledge in both directions between an uncodified, context specific and highly local form to highly codified, abstracted and diffused. It is a model that recognises the difficulty of technology out from a highly localised contecxt s well as technology adoption.

Leonard suggests a model of technological capability that comprises explicit processes that support Boisot’s social learning cycle. She describes them as key innovation activities and are: shared prolem solving; prototyping and

experimentation; implement and integrating technology; and absorbing knowledge from outside the organisation. Using Boisot's and Leonard's models, a composite model of knowledge translation capability can be developed (Savory 2005). This is illustrated in Figure 1.

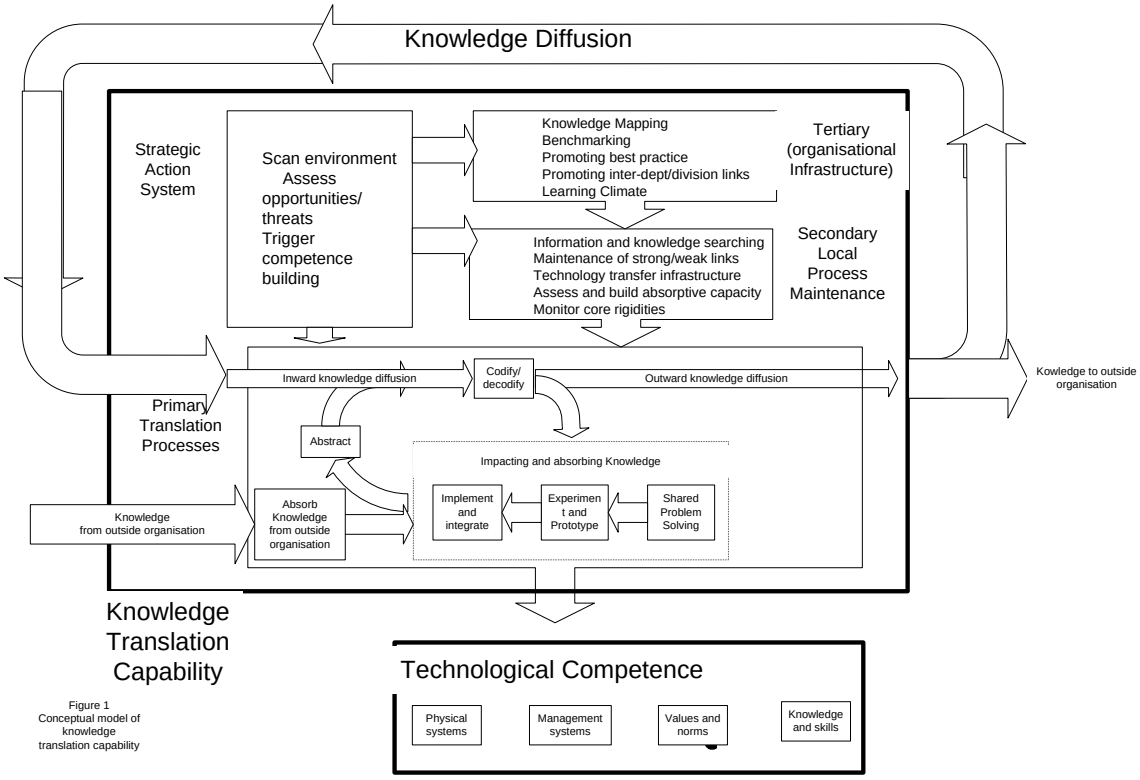

Figure 1
Conceptual model of knowledge translation capability

The implication of the knowledge translation capability model for the NHS, is that any innovation policy must support the model's constituent activities. Policy must recognise that the mode of knowledge production is closer to Mode 2 and must actively support "bottom-up", emergent social structures such as communities of practice (Lave and Wenger 1991; Wenger 1998). Taking a rigid, formalised, bureaucratic and top-down approach to innovation is unlikely to support effective practice-based innovations.

The next section assesses to what extent current NHS innovation policy addresses the issues of innovation of hard and soft health technologies, and whether an organisation wide knowledge translation capability is fostered by such policies.

The Ulcer Clinic: an example of Mode 2 based innovation

The model of knowledge translation capability provides an idealised activity system to support Mode 2 knowledge production. The model can be used to guide the examination of a successful NHS innovation project. Where there are common

features, it is useful to consider how the two pronged policy described above is supportive of innovation more generally in the NHS.

The vascular-surgery out-patient service at Good Hope Hospital, in the West Midlands UK, has undergone a major redesign focusing on the creation of a one stop shop for treatment of leg ulcers (Hayes and Dodds 2003). This represented an innovation in the soft technology of patient care enabled by implementation of a hard technology. The innovation was enabled by innovative use of information and communication technology (ICT) in the form an image-based electronic patient records telemedicine system, allowing information to be shared between hospital and community based NHS staff. This example therefore shows how a service improvement innovation (a soft technology) is enabled by an embedded hard technology. The project is particularly innovative as part of the project involved the development of a software simulator of the new service; this itself was developed within the team responsible both operating and redesigning the new service (Dodds 2005; Dodds 2006). This provides an example of a practice-based innovation comprising both soft and hard technologies. It is a valid example, as the team responsible for the innovation have received national innovation awards (winner of the NHS Innovation Award for Service Delivery 2004 and winner of the HITEA Award for Best Use of IT in the Health Service 2005. Winning these prestigious awards would suggest that this is the type of project that the NHS would like to encourage.

It is useful to identify some of the key characteristics of the project. The characteristics illustrate the operation of a knowledge translation capability and hence mode 2 knowledge production.

The first important feature of the project is the multi-disciplinary nature of the team. The team included specialist medical and surgical staff from the general hospital, and community based nursing staff. This mix of staff was crucial to the successful implementation of the new service design and the implementation of a telemedicine system. This was particularly important due to the inter-organisational nature of the innovation, bridging two NHS trusts a primary and an acute trust. The multidisciplinary approach may also have been a factor in promoting a shared problem solving approach and creative abrasion (Leonard and Straus 1997).

The second important feature of the project is the methodology chosen to develop the project. The project team made an explicit decision to follow a "…research-style approach that would provide objective evidence of benefit to support any proposals" rather than following a "conventional PDSA (plan-do-study-act) method" (Dodds 2005). The approach taken was effectively in accordance with the evidence based principles applied within the NHS to develop optimum solutions to medical and policy issues. By taking this approach, data developed in the project would be regarded as having high validity within the NHS, so easing the negotiation of resources to further the project. An evidence-based methodology can also be better defended on the grounds of needing to protect patients from risk associated to changes in the service design. The methodology adopted could simply be seen as the preferred methodology used by medical staff, reapplied to technological innovation, essentially part of the signature skills that define their expertise (Leonard 1995). This case illustrates that in promoting innovation, freedom to exercise methodological choice is an important factor.

The third feature of the project was that a key member of the team brought a multidisciplinary approach to the project, fusing knowledge of medicine and computer science. The team member was a consultant vascular surgeon who had also gained a degree in computer science. The team member could therefore be described as having an "A" shaped signature skill, skills that allow a fusion between two specialities (Leonard 1995)p.77. The ability to fuse together two specialisms enabled the consultant to implement an ICT based electronic patient record system, that included image based records of patients' ulcers. The consultant was a crucial member of the project team as he represented the mechanism through which process re-design knowledge could be absorbed into the team. This is particularly in the light of the view that many process re-design tools were oriented towards a manufacturing context and that context specific craft skills were available to make use of them in a medical context (Dodds 2005). In this way, it was possible for the highly codified and abstracted knowledge developed on process re-design, to be contextualised into the localised conditions of the NHS. This represents the process of impacting of knowledge into concrete practices (Boisot 1998)p.61. This process is central to a successful knowledge translation capability.

The final feature of the project was that it encompasses mechanisms for extensive experimentation and prototyping. An example of this was in the re-design of the service using a computer simulation. The project team was concerned that any changes to the service design should be based on scientific evidence and so they developed a process simulator that used discrete event simulation to model the pattern of flows through the clinic. The simulator was a key tool for allowing the team to theorise about the service design and carry out virtual experiments with different redesigns. Once tested on the simulator, changes could then be made in the actual clinic. Without the simulator, it would have been very difficult for the team to carry out experiments with new designs. This demonstrated a "learning before doing" approach (Pisano 1996). The overall clinic redesign was carried out as a series of incremental improvements e.g. implementation of an image based patient record system; changes to booking schedules etc. These constituted a series of prototyping stages in the project lifecycle. The participation of hospital and community based staff enhanced these stages leading to better implementation of the changes and integration with existing practices.

This section has used the model of knowledge translation capability to analyse the features of a successful innovation project. The project was driven primarily by NHS staff in the course of their normal work. The project illustrates the importance to this project of several of the sub-systems within the knowledge translation capability model and their inter-relationships.

Implications for the NHS innovation policy

Practice-based innovations are by their nature idiosyncratic. In the example of the ulcer clinic, the presence of a member of staff with dual skills in medicine and computing is rare, yet this was a major factor in the success of the innovation. Whereas a research-based innovation will usually be the result of a carefully planned R&D project, practice-based innovations are likely to be dependent on groups formed for some purely operational purpose. Presence of an innovative group can therefore be based mainly on serendipity. Innovation policy needs to take account of these differences. The use of the knowledge translation capability model can help inform overall innovation policy.

Policy must recognise that practice-based innovations cannot be presumed to be based on either a single hard or soft technology. They are based around an interrelated mix of hard and soft technology, which may have potential use in both the external healthcare products market and the NHS' internal market. Making a false distinction between how soft and hard technologies are treated is simplistic and is likely to lead to inappropriate support mechanisms.

Practice-based innovation is likely to take place across both internal and external boundaries within NHS trusts. Project teams may be formed by staff from across the NHS e.g. hospital and community based staff. Policy should support projects so that bureaucratic barriers to involvement are minimised.

The knowledge translation capability model highlights the interplay between formal and informal innovation processes. Many informal activities, such as those associated with communities of practice, may only be facilitated and are not conducive to direct management. Formal activities such as knowledge mapping can be actively managed. Policy needs to address how both categories of process are adequately supported.

Further research is planned to examine how well formal innovation processes in the NHS support practice-based innovations. Individual case studies of practice-based innovations are planned that will allow a comparison between the "espoused theory" of innovation encapsulated in policy and the "theory-in-use" reflected in the actual processes followed by innovative teams. The knowledge translation capability model provides a basis on which the overall innovation process can be assessed as supporting Mode 2 knowledge production. Wider research is possible in other public sector organisations in which opportunities exist for staff to develop practice-based technological innovations

References

Adler, P. (1986). "New Technologies, New Skills." California Management Review 29(1): 9-28.

Adler, P. S., P. Riley, et al. (2003). "Performance improvement capability: Keys to accelerating performance improvement in hospitals." California Management Review 45(2): 12-+.

Baker, J. (1999) "Creating knowledge creating wealth: realising the economic potential of public sector research establishments A report by John Baker to the Minister for Science and the Financial Secretary to the Treasury", HM Treasury.

Black, N. (2001). "Evidence based policy: proceed with care." BMJ 323(7307): 275-278.
Blackler, F. (1995). "Knowledge, knowledge work and organizations: An overview and interpretation." Organization Studies 16(6): 1021-1046.
Boisot, M. H. (1998). “Knowledge assets: Securing competitive advantage in the information economy”, Oxford University Press.
Christensen, C. M., R. Bohmer, et al. (2000). "Will disruptive innovations cure health care?" Harvard Business Review 78(5): 102-+.
Cohen, W. and D. Levinthal (1990). "Absorptive capacity: a new perspective on learning and innovation." Administrative Science Quarterly 35(1): 128-153.
Cookson, R., D. McDaid, et al. (2001). "Wrong SIGN, NICE mess: is national guidance distorting allocation of resources?" BMJ 323(7315): 743-745.
Culyer, A. (1994). “Supporting research and development in the NHS. A report to the minister for health by a research and development task force chaired by Professor Anthony Culyer”, HMSO.
Custer, R. L. (1995). "Examining the dimensions of technology" International journal of technology and design education 5: 219-240.
Deschamps, J. P. (2003) “Innovation and Leadership” The international handbook on innovation. L. V. Shavinina. Amsterdam ; Boston, Elsevier Science**:** xxviii, 1171.
Dodds, S. (2005). "Designing improved healthcare processes using discrete event simulation." British Journal of Healthcare Computing and Information Management 22(5): 14-16.
Dodds, S. (2006). “Three Wins: service redesign through flow modelling”, Aeneas and Kingsham.
DoH (2002) “The NHS as an innovative organisation, a framework and guidance on the management of intellectual property” London, UK, Department of Health.
DTI (2004) “Knowledge transfer and public sector research establishments (PSREs)”, Department of Trade and Industry.
Gibbons, M., C. Limoges, et al. (1994). “The new production of knowledge : the dynamics of science and research in contemporary societies” London ; Thousand Oaks, SAGE Publications.
Greener, I. (2004). "Health Service Organization in the UK: a Political Economy Approach." Public Administration, Oxford 82(3): 657-677.
Harrison, S. and B. Wood (1999). "Designing Health Service Organization in the UK, 1968 to 1998: from Blueprint to Bright Idea" Public Administration, Oxford 77(4): 751-769.
Hayes, S. and S. Dodds (2003). "Telemedicine: a new model of care." Nursing Times 99(5).
Hippel, E. v. (1988). “The sources of innovation” New York, Oxford University Press.
HITF (2004). “Better health through partnership: a programme for action”, Department of Health.
Howells, J. (1997). "Rethinking the market-technology relationship for innovation." Research Policy 25(8): 1209-1219.
Jones, M. (2001). “An interpretive method for the formative evaluation of an electronic patient record system”. 8th European Conference on IT Evaluation, Oriel College, Oxford, UK, MCIL.
Kogut, B. and U. Zander (1992). "Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology." Organization Science 3(3): 383-397.

Lave, J. and E. Wenger (1991). Situated learning : legitimate peripheral participation. Cambridge England ; New York, Cambridge University Press.
Leonard, D. (1995). Wellsprings of knowledge : building and sustaining the sources of innovation. Boston, Mass., Harvard Business School Press.
Leonard, D. and S. Straus (1997). "Putting your company's whole brain to work." Harvard Business Review 75(4): 110.
Marmot, M. G. (2004). "Evidence based policy or policy based evidence?" BMJ 328(7445): 906-907.
Maynard, A., K. Bloor, et al. (2004). "Challenges for the National Institute for Clinical Excellence" BMJ 329(7459): 227-229.
Mintzberg, H. (1993). Structure in fives : designing effective organizations. Englewood Cliffs ; London, Prentice Hall : Prentice-Hall International.
NHS Institute for Innovation and Improvement (2005). NHS Institute for Innovation and Improvement: Priorities for 2005/06, Department of Health, London, UK.
Nowotny, H., P. Scott, et al. (2001). Re-thinking Science: knowledge and the public in an Age of Uncertainty, Polity.
Nowotny, H., P. Scott, et al. (2003). "'Mode 2' revisited: The new production of knowledge - Introduction." Minerva 41(3): 179-194.
Office of Science and Technology (2000). The Government response to the Baker Report: "Creating Knowledge, Creating Wealth:" Realising the economic potential of public sector research establishments, HM Treasury.
Pisano, G. P. (1996). "Learning-before-doing in the development of new process technology." Research Policy 25(7): 1097-1119.
Reason, P. and H. Bradbury, Eds. (2000). Handbook of Action Research: Participative inquiry and practice, Sage.
Rogers, H., K. Silvestor, et al. (2004). "NHS Modernisation Agency's way to improve health care." British Medical Journal(328): 463.
Rushmer, R., D. Kelly, et al. (2004). "Introducing the learning practice - I. The characteristics of learning organizations in primary care." Journal of Evaluation in Clinical Practice 10(3): 375-386.
Savory, C. (2005). Does the UTTO model of technology transfer fit public sector healthcare services? Working Paper No. 11. Technology Management Research Group, The Open University, UK.
Savory, C. (2005). Translating knowledge to build technological competence. Working Paper No. 7. Technology Management Research Group, The Open University, UK.
Souder, W. E. (1987). Managing new product innovations. Lexington, Mass., Lexington Books.
Swamidass, P. M. and A. Nair (2004). "What top management thinks about the benefits of hard and soft manufacturing technologies." IEEE Transactions on Engineering Management 51(4): 462-471.
UK Government (2000), “The NHS Plan, A plan for investment, a plan for reform”
Wenger, E. (1998). “Communities of practice: learning, meaning, and identity”, Cambridge, U.K. ; New York, N.Y., Cambridge University Press.
Worthington, F. (2004). "Management, change and culture in the NHS: rhetoric and reality." Clinician in Management 12(2): 55-67(13).
Zahra, S. A. and G. George (2002). "Absorptive capacity: A review, reconceptualization, and extension." Academy of Management Review 27(2): 185-203.