0102 Can acquisition of expertise be supported by technology?

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Abstract

Professional trainees in the workplace are increasingly required to demonstrate specific standards of competence. Yet, empirical evidence of how professionals acquire competence in practice is lacking. The danger, then, is that efforts to support learning processes may be misguided. We hypothesised that a systemic view of how expertise is acquired would support more timely and appropriate development of technology to support workplace learning. The aims of this study were to provide an empirically based understanding of workplace learning and explore how learning could be facilitated through suitable application of technology.

We have used the medical specialist trainee as an exemplar of how professionals acquire expertise within a complex working environment. We describe our methodological approach, based on the amalgam of systems analysis and qualitative research methods. We present the development of a framework for analysis and early findings from qualitative data analysis. Based on our findings so far, we present a tentative schema representing how technology can support learning with suggestions for the types of technology that could be used.

Introduction

For many professions, the acquisition of expertise is expected to occur by learning from experience on the job. However, learning from experience is a phrase that has dominated both adult education and learning in the workplace without much critical attention. The medical profession is a prime case of where learning is expected to occur within a complex working environment. Adequate professional training is fundamental in the context of patient safety and quality of care, yet a look at the literature reveals that approaches to professional training are based on little examination or underpinning knowledge of how professional expertise is acquired (Eraut 2004). Although medical education has an expanding body of research in its own right, most of the emphasis has been placed on the formal training years.

Reforms within professional education have arisen in response to public concern over professional inadequacies and a need to increase the standard and structure of training. Accountability has increased and trainees are expected to demonstrate their capabilities more explicitly. Formal curricula now guide their learning. However, these do not take into account the complexity of the working environment. Amongst trainees, there is a perceived lack of connection between curriculum documentation and workplace experiences. This difference is yet to be articulated and trainees thus make little use of their formal curricula.

Despite such reforms, medical education has to cope with shortages of teaching physicians, increasing demands on service provision, shortening of training hours and reductions in funding. Consequently, conditions for adequate workplace learning are often poorly met. Trainees are faced with the challenge of making the most of the experiences they are exposed to. So far, methods to support training have not been based on evidence of where improvements are required.

There is widespread use of technology to support training and it has been recommended, amongst other things, as a way of improving workplace education. Although there are numerous accounts of technological innovations to enhance and support training, most technologies simply act as didactic tools, media of communication, sources of learning materials, or means of delivering assessments. The tools implemented are often limited by a narrow spectrum of facilities. There have been limited advances in technology to support experiential learning in medicine (Greenhalgh 2001). Where technologies have been introduced, it has been done with little prior analysis of the system they are required to support (Childs and Hall 2005).

The changing nature of work practice and increasing demands on professionals to carry out a quality service need to be offset by an increase in the quality of the learning experiences. There is a need to reconsider how technology can be used to scaffold learning with suitable and timely interventions. A clearer view of the how professionals develop expertise within a complex environment is indispensable if improvements are to be fostered appropriately.

In this paper we provide a background to this research area. We provide a rationale for the selection of research methods and analysis, followed

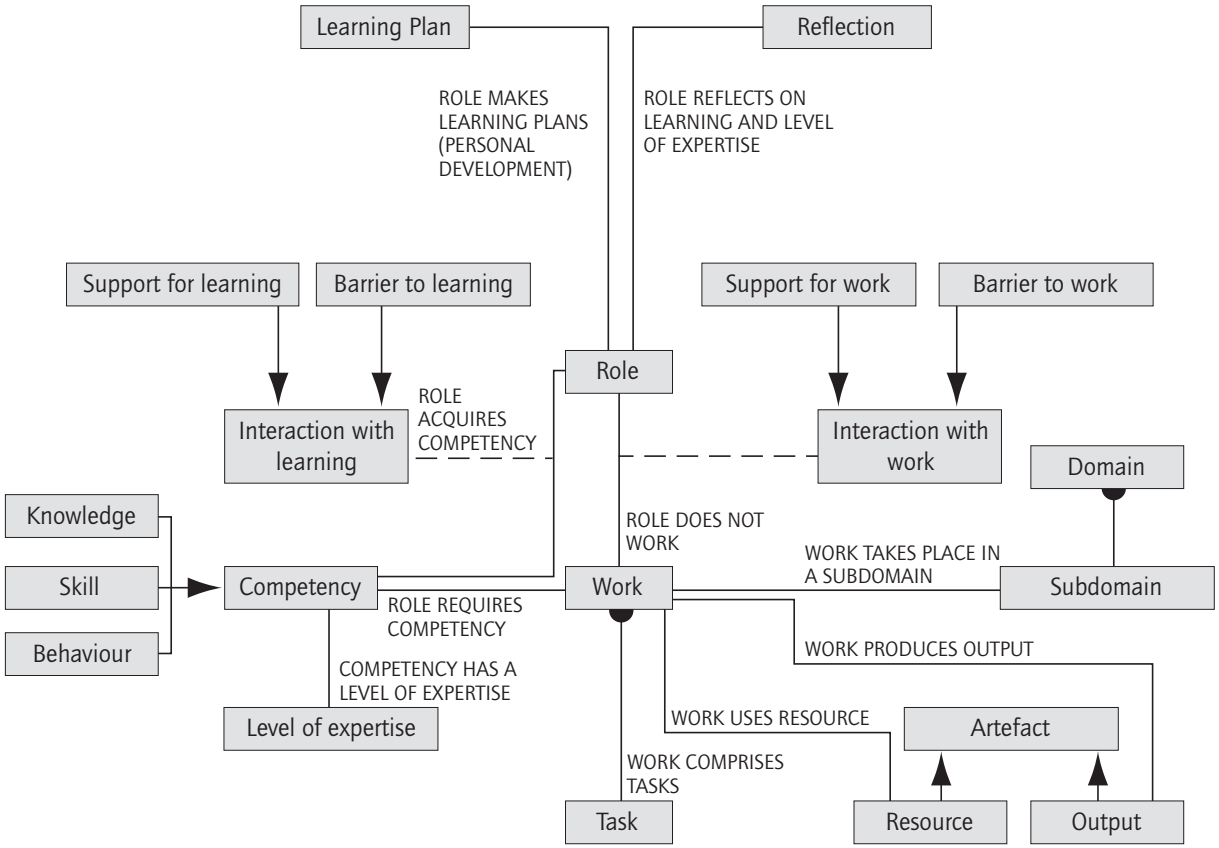
by a case study in progress. Preliminary findings are summarised and the approach evaluated. First steps are taken to identify the ways technology could intervene. We conclude the paper with a summary of limitations and strengths of this approach and outline potential avenues for the future.

Background

The specialist medical trainee is a good exemplar of how complex expertise is acquired in workplace settings. After 4–5 years of formal undergraduate training and a year of satisfactory practice based training, a full registration to practice is obtained. The postgraduate years usually involve a few years of general training, followed by a period of specialist training in a particular field. These latter years of training are essential in preparing doctors for independent practice and are crucial in shaping their habits, behaviours and attitudes towards patients. The training programme amounts primarily to a form of apprenticeship, interspersed with formal didactic teaching. Breadth of experience is gained by working within a variety of hospital organisations and specialist departments. As service demands increase, trainees are increasingly required to work under conditions of time pressure. Heavy workloads, long working hours, fatigue and perceived lack of support can lead to stress, dissatisfaction, inadequate job performance, and burnout amongst trainees (Veasey et al. 2002). Despite this challenging environment, it is necessary for doctors to acquire a wide and complex range of knowledge and skills and integrate them appropriately into their practice. They do this through a process of progressive independence, requiring less supervision until they become expert practitioners (Kennedy et al. 2005).

Attempts to characterise workplace learning have been made by several researchers (Hager and Halliday 2006) and have resulted in increased awareness of the significance of informal learning processes. In contrast to

Figure 1: The system framework model



formal learning, which tends to be structured and more institutionally based, informal learning is holistic, contextual, and activity/experience-based. It is often unplanned and unpredictable, arising in situations where learning is not the main aim. As a result, the learner is often unaware of the extent of their learning, even though they may be aware of their ability to perform the job. Studies in this area have alluded to the inseparable and implicit nature of learning at work and the importance of tacit knowledge learned in the workplace (Eraut 2004).

Most of our understanding of how professionals acquire expertise comes from the cognitive psychology literature. Cognitive processes based on the transformation of experiences, through reflection and action, have been highlighted within experience based learning (Kolb 1984; Schön 1983). Such theories have provided insights into how physicians learn to solve clinical problems, whereby previous clinical experiences prove fundamental in helping to solve future problems. Dreyfus and Dreyfus (1986) propose that practitioners acquire their skills in practice according to progression from novice to advanced beginner, competent, to proficient and finally to expert. The novice may depend on concepts learnt through formal processes or the use of guidelines. The more experienced practitioner tends to learn through more informal self-initiated mechanisms, constructing their knowledge themselves in the context of their practice. The model emphasises pattern recognition, intuition, and reflection as critical to the development of professional skills. Critical to the acquisition of expertise is for the more expert practitioner to encounter less familiar or more complex problems. These require adaptation of the learnt scripts and more critical thinking (Schmidt, Norman, and Boshuizen 1990).

Social theories of learning have also provided some invaluable insights into workplace learning. Such models suggest an important social dimension to learning. Professionals in the workplace learn from interactions with others within the environment. Central to the learning process is participation in activities, which fosters and is fostered by socialisation within a community of practice (Lave and Wenger 1991).

Methods

We had to choose a method capable of describing how expertise is acquired. It would therefore have to tackle an area of high complexity that is not well understood. The one chosen was an amalgam of systems analysis and qualitative analysis, aiming for synergy between the two fields. The dual approach would allow a systemic view to be taken and an interpretation within complexity, but also arrive at pragmatic, solutions in the face of that complexity. Qualitative methods enable exploration of phenomena in their natural settings, characterising the meanings, experiences, and views of all the participants through rich and detailed descriptions. Systems analysis generally uses semi-formal visual models as a way of filtering out the complexity of large systems. In abstracting complexity, it becomes possible to identify areas in the system that might be enhanced or better supported. Representation of the workplace learning system through visual models (created in the Unified Modelling Language (UML)[1]) allows development of a shared representation of how trainees are learning and an understanding of where learning could be facilitated. System modelling provides the basis for requirements specification for people-based and technology-based support of the workplace learning system.

Case study

This paper reports a case study that is partially completed but already yielding useful outputs. Doctors in rheumatology specialist training spanning

1 Unified Modelling Language www.uml.org

3 regions of England (North-East, North-West and West Midlands) are being recruited into the study. Approval for this work has been granted by the National Research Ethics Service and written informed consent has been obtained from each participant. Data are being obtained by two methods: Observation and Audio Diary.

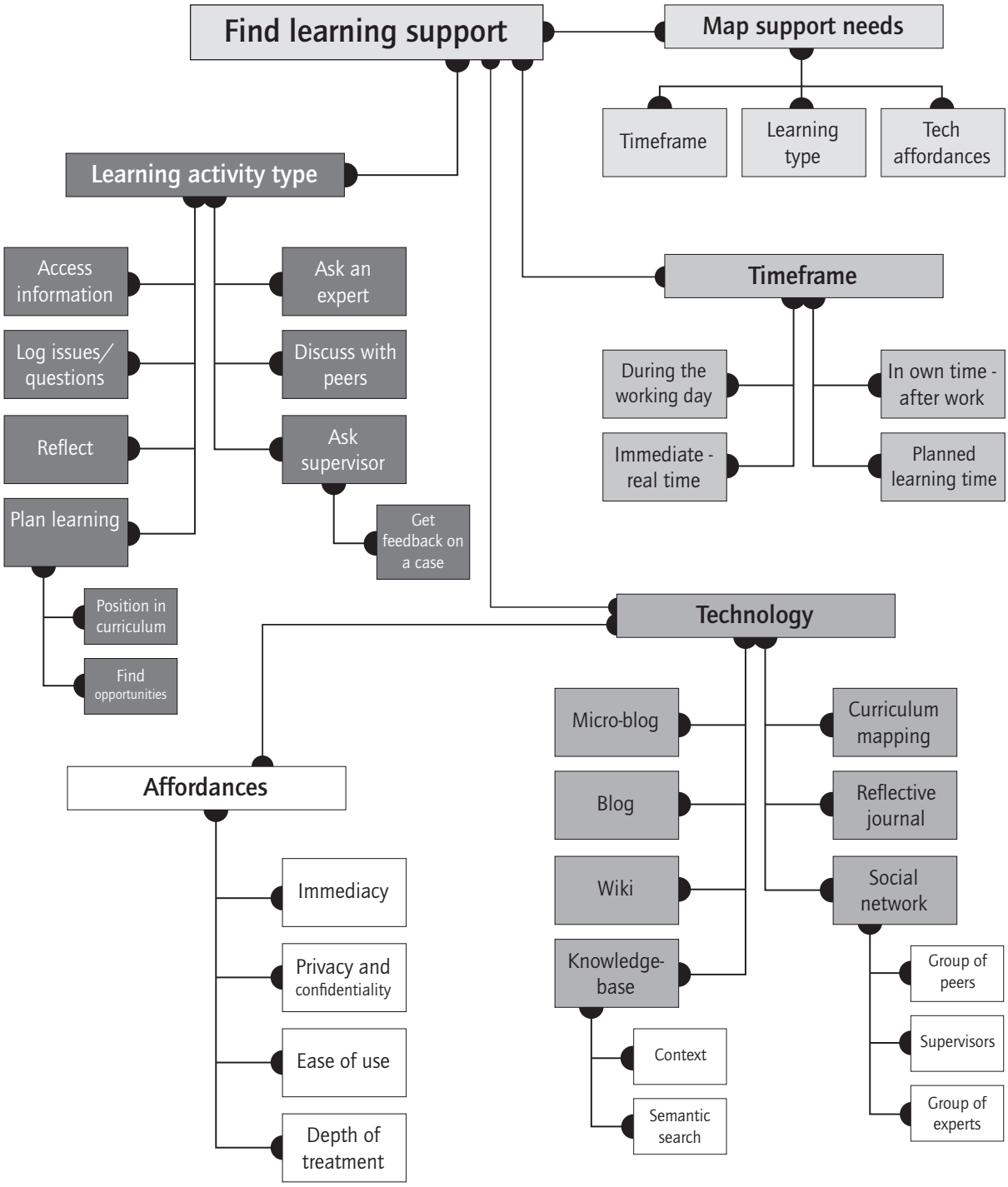
Observation

Observation of trainees in their workplaces was chosen to allow the workplace processes that lead to learning, to be captured for subsequent analysis. Abstracting out parts of the system which are important for understanding learning requires a broad analysis. A purposive sampling approach was therefore adopted to achieve maximum variation. A variety of trainees were sampled across a breadth of work based activities and settings. Two researchers (P.S and H.D), whose different disciplinary backgrounds gave them different perspectives on the research field were chosen to carry out the observational work. P.S. is a doctor familiar with the research field and participants under study. H.D is a systems analyst with no prior knowledge of the research field. The final goal is to conduct four observation periods (3–4 hours) per month over 1 year. A non-participatory approach to observation is being used. Brief discussions in between activities, or short

Table 1: Qualitative analysis findings

Framework Category/Theme	Examples of Findings
Q1 Domain	Hospital: Teaching, District General, Community.
Sub-domain	Out-patient clinic, In-patient duties, Clinical meetings.
Q2 Role	Specialist trainee, Patient, Medical students, Consultant, Junior doctors, Nurses, Allied health professionals, other medical teams sharing care.
Q3 Work	Clinical: reviewing patients in many contexts, taking case histories, clinical examination, providing advice to patients, making clinical decisions, giving and requesting specialist advice, interpreting investigation results, carrying out clinical procedures. Generic: preparing for patient reviews, giving and receiving updates of current work, requesting investigations, reports and appointments, attending meetings, teaching, clinical research, searching for appropriate clinical evidence, reading books and journals, paper work, audio records.
Q4 Artefact (Resources and outputs)	Resources: Patient appointment list, Patient case records, codified information (e.g. Google, British National Formulary), task lists, clinical guidelines, procedural and clinical investigation artefacts. Outputs: Investigation results (e.g. radiographs), clinical specialist opinions, treatment plan.
Q5 Support for work	Patient records system, computerised clinical workstation, translator services, laboratory services, other clinical specialists, clinical support staff.
Q6 Barriers to work	Disorganised patient case records, non-integration of support systems, lack of resources e.g. appointments for patient review or clinical investigation
Q7 Support for Learning	People: Consultants, peers, patients, allied health professionals, other specialists. Artefacts: Patients case records, work-based assessments, codified information (sourced from people, internet, books, journals), tacit knowledge shared between the team. Resources: Case based discussions, formal teaching sessions, feedback on performance Efficiently run outpatient clinics with appropriate allocation of cases, variation of work activities and case-mix.
Q8 Barriers to Learning	Heavy workload, shortage of staff, insufficient time to pursue personal goals, insufficient communication with team, lack of reflection in action, individual persona.
Q9 Competencies	Generic skills: personal organisation, working as a team, supervision and teaching, negotiating the organisational system. Clinical skills: Communication (e.g. rapport building, counselling, negotiating agenda), clinical decision and management, diagnostic reasoning, procedural skills.
Q10 Level of expertise	Novice trainee demonstrates high level of competency in generic skills. Requires direct supervision in specialist clinical skills. Move to autonomous practice is dependent on complexity of competency being developed. Expert trainee demonstrates high level of competency in a range of generic and specialist skills. Works autonomously in practice with arms length supervision. Feedback mainly requested to confirm adequacy in decision making skills and competence.

Figure 2: Mapping support for workplace learning



debriefing interviews with participants following the period of observation, are being carried out when possible. Observations are recorded as detailed contemporaneous field notes and researcher debriefings following each period of observation. Field notes are transcribed immediately afterwards. Inter-observer concordance will be verified by comparing field notes of observations carried out in tandem.

So far, 29 hours of observational fieldwork in three hospitals have been completed including: General and specialist outpatient clinics (n=5), review of in-patients during ward rounds (n=4) and clinical meetings (n=1). Participants have included six specialist trainees ranging in seniority from first to seventh year; they have included both UK (n=3) and non UK

graduates (n=3). Further purposive sampling of trainees will be carried out to observe a range of procedural skills, interactions between specialist teams, clinical meetings, and teaching activities across different hospital settings.

Audio diaries

Most studies attempting to characterise internal processes of learning have used interviews. A novel approach is to use audio-diaries. In contrast to interviews, diaries allow participants to record their experiences contemporaneously, resulting in a higher level of recall (Knight and Sweeney 2007). Trainees are being asked to report salient experiences in their workplace activities, which they find more or less valuable as learning opportunities. In education research, this approach has been useful tool for exploring what people find difficult or stimulating in their work and for discovering experiences that are perceived as being particularly meaningful. Participants are given verbal and written guiding prompts. Trainees have been asked to maintain their diaries over 7 clinical working days, which may or may not be consecutive. Analysis of the diaries will include an audio-analysis to capture points of emphasis and expression, followed by a detailed analysis of written transcripts. To date, eleven specialist trainees have completed audio-diaries.

Data analysis

A generic system model was developed to provide an initial set of nodes to code the observation notes and transcripts of the audio diaries. The model was based on an approach used to elicit system requirements from domain experts in which they engage in facilitated discussion or system modelling activities around a set of 5 key questions (Dexter 2007):

1. Where are we? (Our workplace domain and its boundaries)
2. Who is here? (The roles (areas of responsibility) of people here)
3. What are we doing? (The tasks given to the trainee to carry out)
4. What supports our work? (Needed systems and services around the domain)
5. What are we using and producing at work? (Resources and outputs of the tasks)

The questions are an expression of a working system but do not specifically address a workplace learning system. The model was therefore extended and documented as a UML Class Diagram (Figure 1).

Contribution

From this model of the system, the set of coding nodes for the first iteration of qualitative analysis of the data was:

1. Domain (where the work is taking place)
2. Roles (people and their responsibilities)
3. Work (the set of tasks that the trainee is carrying out)
4. Artefacts (resources for doing tasks and outputs from tasks)
5. Support for work (external systems and services needed to complete tasks)
6. Barriers to work (things that get in the way of efficient or effective work)
7. Support for learning (people and things that are around to help workplace learning)
8. Barriers to learning (things that get in the way of workplace learning)
9. Competencies (knowledge, skills and personal qualities required for a task)
10. Level of expertise (advancement of the trainee towards expert standing)

We are currently applying the framework to the first sets of data collected.

All the data coded against each category (node) will be identified and examined to establish analytical subcategories. New themes which may be discovered during analysis will be back checked against earlier coding using the process of constant comparison. All four members of the research team will code a number of transcripts separately to check their degree of concordance. Data analysis and collection will be iterative to allow purposive sampling and exploration of new lines of inquiry.

A sample of the findings is presented in Table 1 in terms of the ten nodes that formed the basis for the analysis.

The acquisition of competency in the workplace

The combination of qualitative research methods and systems analysis is generating useful outputs. Our results are beginning to indicate how trainees are learning. Through their work, trainees acquire a complex range of competencies, with several different knowledge types being utilised within any one activity. Data suggests that codified knowledge assists them in their practice. A cultural knowledge of how to negotiate the organisational system is also a necessary pre-requisite to their performance at work. Activities which involve participation within a team appear to be particularly associated with learning outcomes. Through social interactions and team dialogue, knowledge is frequently shared and contextualized within its narrative. This is usually within clinical case based scenarios or other forms of story telling. They perceive their learning to be more restricted during activities in which they are less socially supported. In some instances, trainees describe a hierarchical approach used by supervisors to tests their individual knowledge. In other instances, they describe how team dialogue and feedback proceed non-confrontationally. Through socialisation the trainee is given the opportunity to learn by modelling their behaviour on the activities, actions and knowledge of those around them.

'I found it very useful going through the differential with the consultants as it gave an opportunity of understanding the thinking pattern which is how I feel that I best learn, that is to say, understanding how other people think and adapting that into my thinking strategy if I feel that it's appropriate.'

Participation in authentic practice is fundamental to the acquisition of expertise. Within the clinical scenario, the patient acts as the primary learning resource. This might be through direct interaction with the patient or through discussion of a case with others. Trainees describe how they acquire expertise in assessing and managing a particular case by experiencing it repeatedly within different contexts. Some trainees reflect on how a change in practice can be stimulated by a recent discussion, feedback, or error based around a similar case. The busy schedules of most trainees, however, seem to leave little room for self-initiated reflection. There is some evidence that the study itself is acting as a form of intervention, by encouraging trainees to reflect on their learning.

How might this study feed into the design of technology or people systems?

Findings could potentially be fed into the design of technology-based or people-based systems in a number of ways. Design of the right kind of technology support for workplace learners needs to consider the types of activity taking place in the working day, the timeframe in which support is needed or in which the learner is able to use the technology and the particular affordances of the technologies. Figure 2 shows these three aspects and how they may be used to 'map' a support requirement to the most appropriate technologies.

There is a rich array of tools available in the web 2.0 world to support learning (Franklin 2008) but they have to be offered in a way that will serve a learner who has very little free time during the working day and already has to deal with a very complex environment. The different technologies may be used in combinations with each other and with bespoke software applications. In this case study, early findings suggest that one of the most useful technologies might be a social networking platform to support groups of peers and of experts. This platform would offer a range of tools supporting conversations, such as micro-blogging for obtaining immediate response to quick questions and obtaining feedback on clinical decision making. Discussion forums or wikis could be used for following opinion on particular topics. A reflective journal (either text or audio) which would allow selected parts to be shared with the community is also a candidate technology for enhancing workplace learning.

The theory of workplace learning and sharing of expertise in communities of practice as laid out by (Wenger, Mc Dermott, and Snyder 2002) has made a significant contribution to understanding but may not deal sufficiently with the community boundaries in complex institutions (Fuller et al. 2005). The learners observed here pass through a number of different but overlapping 'communities' in their work and any group management in a social network would need to reflect this.

The learners require a map of areas of expertise and the appropriate channels of access to experts in each. Their interactions with located experts will vary in response-time and degree of formality and any provided technology will be required to support this. It will be necessary to establish the most useful types of social interactions (Brouns et al. 2008; Walter, Battison, and Schweitzer 2008) since it would be counter-productive to expose the learners to 'noise' in the form of connections to people who are not valued or trusted, or are not relevant to the area of expertise. Examples of design for systems to support the location and reuse of tacit expert knowledge can be found in the engineering sector (Collison and Parcell 2001;Woo et al. 2004) and provide a basis for part of the on-going research design.

Evaluation

The study so far has a number of limitations. The data source is confined to a single discipline and specialty within the medical profession. The number of participants observed thus far is limited and, as yet, we are still continuing to find new themes emerge from our data. Data collection will continue until no major themes emerge from new data collected. However, the study is still in its early stages and requires further purposive sampling before saturation of data is reached. Data collection in this kind of study relies on voluntary participation. The quality of data is heavily dependent on access to the research field for observation and on the motivation of the participant keeping the audio diary. To enhance transferability, sampling across other medical disciplines may be useful.

Although observational research is relatively time consuming, the effort has yielded rich and descriptive. The iterative process of data collection and analysis will allow us to see when new data is yielding no new major findings. This will ensure data collection is limited to that necessary to yield useful outputs. Using a framework approach to the analysis allows our findings to be interrogated for reproducibility by independent researchers, thereby increasing the construct validity of the findings.

The findings suggest that our approach is also taking us closer towards developing a better understanding of how expertise is acquired in the workplace. The use of qualitative research methods have provided us with the rich descriptive data required to analyse this area of study. The selection

of data sources have proved useful in providing different perspectives on learning. Triangulation of these data sources to gather internal and external perspectives on learning appears particularly pertinent to yielding rich findings. The observations carried out so far have provided a more systemic overview of the workplace environment, particularly in relation to the organisational factors, which are supportive and constraining to their work. The observations are providing useful insights into areas where learning occurs more implicitly. The use of two observers has been helpful in obtaining different perspectives of the learning environment. Sampling purposively across a broad number of settings and activities is allowing gradual construction of a systemic overview and comparison of the learning environment across different contexts. This has led to a decision to continue to develop this approach to direct the rest of the study. The methods developed and the approach used within this study, have the potential to be adopted usefully by others who are carrying out research in this field. It is expected that at least some of the findings will be generalisable to a wider arena, particularly within the health profession.

Conclusions

In conclusion, the chosen methods are allowing us to characterise how expertise is acquired in the workplace. The combination of qualitative research methods and systems analysis has led to a first iteration framework from which to analyse the data. The framework is leading us towards a systemic representation of trainees' work-based learning environments and we have shared some of our early findings in this paper. Our analytical framework has provided a starting point from which to interrogate each aspect of the model further. Analysis of interrelationships between framework categories will hopefully lead to further conceptual development within our findings.

As the research develops iteratively, further categories for analysis are likely to be identified. They will be incorporated, leading to refinement of our first iteration framework. Analysis of workplace learning is also likely to benefit from further triangulation with additional participant interviews. This will allow us to explore their trainee views of where and how learning can be facilitated appropriately.

From our analysis of the workplace so far we have established design principles for workplace learning support. We suggest that any technology or other types of support need to take into consideration the types of activity taking place in the working day, the timeframe in which support is needed or in which the learner is able to use the technology and the particular affordances of the technologies. A major finding from the study so far has been that the acquisition of expertise is facilitated through the sharing of tacit knowledge and expertise, within a community of practitioners. We tentatively propose one useful technology might be some sort of social networking platform. This could facilitate the support of groups of peers and experts in a shared learning practice and exposure of expert knowledge within a wider community of practitioners. We bear in mind that avenues other than technology might also appropriately support learning. Modified work practice, which facilitates the sharing of expertise on a broader level, might be a potential solution. This might, for example be through changing of dialogue between practitioners or alternative arrangement of meetings within a team.

In summary, the findings from his study will provide a useful representation of how expertise is acquired in the workplace and the curriculum as it is experienced by the trainee. The approach used will provide requirements specification to inform the development of technology to facilitate workplace learning. The study contributes to technology advances by basing new potential innovations on sound empirical evidence.

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