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Learning to prevent disaster: An investigation into methods for building safety knowledge among new engineers to the Australian gas pipeline industry

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ABSTRACT

Safe operations are critically reliant on the practices and expertise of companies and their personnel. Their importance has been highlighted throughout accident analyses where warnings have been shown to go ignored, and the scale of what could go wrong misjudged. A common view of learning in professional fields has been one of knowledge 'transmission' through training courses and seminars. This article draws attention to the more informal and experiential means by which knowledge is acquired.

Grounded in the literature on high reliability theory, organisational learning and naturalistic decision making, this ethnographic research examines the learning experiences of 'young' engineers in the Australian gas pipeline industry. The particular focus is on young engineers' appreciations of safety and their role in its continuation. It argues that, in addition to formal knowledge delivery, young engineers and their colleagues are relying on informal mentoring and experience in their acquisition of safety knowledge and professional expertise more broadly.

The article is based on qualitative interviews with 34 gas pipeline engineers including new people to the industry, their managers, and technical experts. The work is investigative rather than hypothesis-testing. It concludes with some areas in which further work would be valuable, including an evaluation of the extent to which informal learning methods are appropriate in a hazardous industry context, and the formal organisational features that might effectively support them.

1. Introduction

Safe operations in hazardous industries are critically reliant on the professionalism of personnel, but organisations often fail to recognise this or properly support its development (Hayes, 2010). Its importance has been highlighted throughout accident analyses where warnings have been shown to go ignored, and the scale of what could go wrong misjudged. At Deepwater Horizon, a cause of the blowout was identified as a 'faulty mental model' of the personnel running tests (Hopkins, 2012). The workers employed on the platform simply did not have the discipline background to imagine possible causes of their test results. Similarly, analysis of the BP Texas City Refinery disaster captured how there can be blindness to the risks of a major accident (Hopkins, 2010). These short-comings need not be viewed as individual failures, but reflect how – at an organisational level – the necessary appreciations of what can go wrong and expertise to manage these risks can be underemphasised.

The importance of professionalism and expertise to safe outcomes has emerged as an important issue in the Australian gas pipeline industry as the effects of a recruitment gap are beginning to be felt. To date, the Australian industry has had an excellent record regarding safety, due, in part, to the safety values and expertise of its professional staff (Bonar and Tuft, 2009). However, the industry has an ageing workforce, and is facing the imminent retirement of many of its key experts. These issues are not unique to the Australian industry. Particularly the European and North American industries are facing similar challenges (Gomes, 2012; Jinks, 2012). These challenges prompt the question: How is pipeline engineering expertise maintained as new generations take up increasing responsibility for key decisions? A common view of learning in professional fields is one of knowledge 'transmission' through training courses and seminars (Brown and Duguid, 1991; Gherardi and Nicolini, 2002). However, this article presents an additional view where, congruent with the literature on naturalistic decision making and organisational learning, learning also occurs through working alongside colleagues, hearing their stories, getting feedback, and on-the-job experience (see Duguid, 2005; Klein, 1999, 2009; Knorr-Centina, 1999; Lam, 1997, 2000; Lam and Lambermont-Ford, 2010; Legat, 2008; Nyiri, 1988; Turnbull, 2000; Wenger, 1998).

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This article examines how new members to the Australian gas pipeline industry are learning about safety and their role in it. As it is the first enquiry into the experiences of new members to the Australian gas pipeline industry, it is investigative rather than hypothesis-testing. It captures young engineers' primary learning methods for building safety knowledge and professional expertise, both through the reflections of young engineers themselves and their colleagues. In the context of the literature, it then discusses these findings and raises questions for further empirical investigation. It argues that the informal and experiential learning opportunities identified by research participants can be expected to play an important role. However, this finding requires evaluation, particularly given the unique challenges of working in a hazardous industry. It suggests that opportunities for formally supporting informal and experiential learning methods warrant further investigation.

2. Expertise development in professional organisations

This article takes an organisational view of safety (see Hayes, 2012; Hopkins, 2000, 2005, 2010, 2012; Reason, 1997; Snook, 2000; Vaughan, 1996). The literature on high reliability organising tells us that safety is achieved when qualities such as a deference to expertise are supported at an organisational level (Weick and Sutcliffe, 2001; Weick et al., 1999). In engaging with this claim, a concern of the safety literature has been the balancing of procedures and expert judgements (Hale and Borys, 2013a,b; Hayes, 2013). Equally, out of analyses of the Deepwater Horizon and Texas City disasters, another concern has been the mental models of personnel; specifically, the extent to which they have an appreciation of major accident risk as well as personal safety hazards (Hopkins, 2010). This is valuable research, and has informed the present work.

However, at a more foundational level, a question less-addressed is how this valuable expertise and associated appreciations of safety are developed among personnel (exceptions include Nesheim and Gressgård, 2014; Størseth and Tinmannsvik, 2012; Wahlström, 2011). To progress our understanding of this question, this research looked to the work on naturalistic decision making and organisational learning to appreciate the processes and challenges of expertise development in organisations. This literature provides a theoretical foundation from which to appreciate the research findings. Later in the article, the author discusses the extent to which its arguments can be expected to hold water in the hazardous industry context, a question that is ultimately found to warrant further investigation.

Foundational to any consideration of how somebody *becomes* expert is understanding what distinguishes experts from novices. Over the last 50 years, research in social sciences has moved from understanding expertise in terms of 'logical' knowledge and ability, to understanding it more in terms of wisdom and competence (Collins and Evans, 2007). In other words, expertise is reflected more in what someone can do, rather than what they can learn. A key influence in this shift was Polanyi's (1958, 1966) concept of 'tacit' knowledge, which captures understandings that can be difficult to put into words, not completely conscious, or just plain unnoticed. This tacit knowledge has been identified as vital to the decision making of experts who work in challenging, critical, and extremely time pressured contexts. For example, experts across multiple hazardous specialties were found to be reliant on knowledges that were unconscious and/or unarticulated (Klein, 1999). It was this tacit knowledge that allowed them to make difficult decisions under pressure with a high degree of accuracy.

Through these studies of experts, researchers have identified sources of this knowledge, and how it functions. Much expert knowledge has been found to be acquired through experience, and drawn on through pattern matching and mental simulation (Klein, 1999). This means that expert knowledge is located in practices, not in rules, procedures, and books (Collins and Evans, 2007). Nyiri (1988, p. 20) explained: 'One becomes an expert not simply by absorbing explicit knowledge of the type found in textbooks, but through experience, that is, through repeated trials, "failing, succeeding, wasting time and effort, ... [and] getting a feel for a problem"'. At least initially, this experience is likely under the guidance of others. This suggestion is congruent with Wenger's (1998, p. 4) argument that learning is a process of social participation with learners 'being active participants in the *practices* of social communities'.

This vision of expertise development is somewhat at odds with the types of learning that are often deferred to in professional and technical fields such as engineering. Young engineers join the pipeline industry with a minimum knowledge acquired through a Bachelor of Engineering degree in a relevant discipline such as mechanical or chemical engineering. This qualification gives an engineer foundational technical knowledge and skills. However, this knowledge is not pipeline specific, and it does not necessarily capture the safety practices that contribute to the prevention of major accidents. This has been a great concern for the industry, as particularly in Australia there are not the economies of scale to offer this training at, say, a Masters level. Perhaps encouragingly, what the literature on expertise development suggests is that such formally delivered theoretical knowledge does not equate to expertise anyway. Rather, becoming expert and developing a disposition towards practices that maintain safety requires learning within an industry context which may include formal courses, but relies on experience and learning informally from colleagues.

This does not mean that building expertise is simple. Challengingly, the tacit knowledge that distinguishes experts is not simply passed on. Tacit knowledge is context specific, embedded, and tends to be 'sticky', not quickly or easily transferred (Lam, 1997, p. 974). This is particularly problematic in professional organisations, where formal knowledge and qualifications are given greater importance than the mastery of what might be termed practical skills (Lam, 2000). As such, professional systems geared towards specialisation, codification, and individual learning tend to be inherently weak in the development and sharing of tacit knowledge – and by extension, expertise – because they do not support the tacit knowledge conditions of collective learning, strong social networks, and experience.

These traits of expertise and the means by which they are built point to the importance of experience and informal mentoring processes, including working with others, hearing and sharing stories, and generally getting guidance. This is incongruous with the organisational and institutional factors present in the pipeline industry that emphasise formalised learning opportunities and theoretical knowledge (Lam, 2000). This is a common problem faced by professional industries, and it represents a challenge to expertise development that needs to be negotiated creatively.

3. The research

This research project was designed around a 'real world' concern that the Australian pipeline industry has about the impact of generational change on safety outcomes, particularly in terms of major accident prevention. The two primary questions for this research were: How do young engineers joining the pipeline industry understand safety? And how are young engineers learning about safety, and developing necessary professional expertise? The purpose of this research was to give a preliminary assessment of how generational change within the pipeline industry is impacting on safety