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The role of mobile ICT in repair worker communities of practice

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The role of mobile ICT in repair worker communities of practice.

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Abstract

The article addresses the lack of focus, in the literature on work and communications technology, on the role played by communities of practice (CoPs) in mediating the impacts of technology change on work. It is argued that the particular characteristics of CoPs, the fact that they are regarded as an end in themselves by community members, make them a key part of the technology-organisation dialectic. By examining the role played by CoPs, it is possible to gain a better understanding of the relationship between work and technology - in particular the unintended consequences of technology change for work and, indeed, for CoPs themselves.

Keywords: Communications, Technology, Change, Communities of Practice, Repair Workers

Introduction

Increasingly, communities of skilled mobile workers are finding their work shaped by a growing range of flexible and mobile information and communication technologies. Knowledge and experience are being replaced by increasingly intelligent expert systems; while time with colleagues and managers is being replaced by interaction with decision support. Communities of practitioners (CoPs), including police officers (Author A) consultants (Agostini, et al., 2005) health and care workers (Clark, Nguyen and Sweller, 2006), sales people (Schlosser, (2007) and repair workers (this article), are on the front line of these changes. The technology itself is part of a relentless drive toward seeking greater workforce efficiencies. These efficiencies are gained, primarily, by individualising workers – that is, by reducing the need to undertake lengthy training and reducing the need to ‘return to base’ to use office-bound technologies, meet managers or interact with colleagues. While this phenomena has been researched in terms of its impacts on the individual worker especially work intensification (Bittman, Brown, and Wajcman, 2009) and new challenges for management (Schlosser, 2007; Agostini, et al. 2005) it has not been researched in terms of the role played by incumbent CoPs in mediating and shaping the impact of these technologies on the experience and organisation of work, or indeed, in terms of the likely transformative effects on CoPs themselves. This article examines the simultaneous re-shaping, in use, of both technology and community in the case of boiler repair engineers.

In the case study presented, the workforce was comprised of skilled domestic gas boiler repair technicians, who were reliant upon their community of practice to capture and distribute essential job-related knowledge. The diagnostic technology introduced to replace that knowledge, along with other organisational changes aimed at keeping technicians in the field and working independently longer, failed to fully have that effect. Although the technology was well liked by the technicians, and not resisted, incomplete diagnostics and rapidly evolving boiler technology, meant that technicians continued to rely on their community for knowledge. Ironically, seeking to maintain the community involved the use of yet another technology – personal mobile phones. As will be discussed, the use of mobile phones had its own unanticipated effects on the community.

This research also speaks to the strong current of research that characterises information and knowledge-based systems as failing to impact positively on work - largely because of their ongoing failure to bridge the gap between the reality of practice ‘on the ground’ and a reified version of practice as it is conceived of by management and designers (Brown and Duguid, 1991, 1998, 2000, 2001; Orr, 1996; Heath and Luff, 1996; Brady and Davies, 2010; Heath et al., 2000). What Brown and Duguid (1990) have referred to as the difference between canonical and non-canonical work. Observations from this research, however, suggest that technology is designed with increasing degrees of ‘reality on the ground’ captured and incorporated. This article, while not losing sight of the insights offered by critical accounts of technology, is deliberately about the impacts that technology *does* have.

The article proceeds by outlining the literature on technology change and work. This is followed by a discussion of the nature of repair work and the functioning of its attendant

communities of practice together with a discussion of the role that workplace technology has played thus far in repair work. A methodology and overview of the research is followed by the empirical material, which examines in detail the experiences of repair technicians of successive waves of organisational and technological change. A discussion of the broader implications of the relationship between technology change and communities of practice concludes the article.

Technology and work.

Workplace technology, mechanisation and latterly, information and digital technology, has a long history of threatening livelihoods, reducing workers' pay and security and 'de-skilling' work (Braverman, 1974; Blauner, 1964; Sennett, 1998; Seddon, 2008 and Head, 2005). The history of work-place technology suggests that managers are instinctively drawn to technologies that will reduce their dependency on expensive, skilled and potentially itinerant labour (Ferne and Metcalf, 1988; Kaplinsky, 1984). The central argument of the 'de-skilling' thesis that technologies simply 'impact' on work, stripping away skills, autonomy, interest has been criticised by contemporary social theorists - primarily for its technology determinism. Firstly, it is argued, technology is introduced for a variety of reasons, not all which are detrimental to the workforce – technology can also result in 'up-skilling' (Bain and

Taylor, 2000; Whalley, 1984). Secondly, workforces are not passive in the face of technology change and will play a key role in shaping how technology is used in practice (Grint and Woolgar, 1997; Leonardi and Barley, 2010). The eventual impacts of technology, when explored from the perspective of actual use, are difficult to predict. The use of mobile phones at work, for example, now extends far beyond the imaginations of their designers (Hislop and Axtell, 2011; Matuski and Mickel, 2011). Orlikowski and Iacono (2001) have likewise stressed the inherent malleability of ICT systems in use.

In arguing that CoPs have a particular role to play refracting, and even resisting, the effects of technology change this article accords broadly with the ‘constructivist’ view of workplace technology, outlined above. However, in light of broader findings, this article cautions against over-stressing the power of the CoP or ‘the social’ to resist the ongoing and insistent pressure for change that comes from the latest workplace technology. The history of workplace technology and repair work, of which this case study is a part, is the history of relentless individualisation through successive waves of workplace technology change. As technologies improve, and the view here is that they are, this pressure grows. This article explores the role played by CoPs in both resisting and yielding to that transformative force.

Repair work and communities of practice

Despite their increasing importance to the economy, the work of repair engineers has largely been ignored in the academic literature (Dant, 2010; Graham and Thrift, 2007). Repair engineers typically have high levels of skill and enjoy high levels of autonomy (Dant, 2010; Graham and Thrift, 2007) while incorporating action-centred, tacit learning and ingenuity in the application of knowledge to problem-solving (Dant, 2010; Graham and Thrift, 2007).

Individual repair engineers, however, cannot have knowledge of every possible fault in every

possible machine (there are, for example, about 1,500 boilers presently on the UK market) so it is usual that technicians rely on one another to share the burden of this knowledge. Thus, 'Communities of Practice' (CoPs) are a typical feature of technical repair work.

The CoPs concept captures the observation that workers often form recognisable cohesive communities. CoPs typically emerge among groups of individuals who engage in similar work-related activities and have similar interests (Lave and Wenger, 1991; Brown and Duguid, 2001; Brown and Duguid, 1998; Wenger, McDermott and Snyder (2002). CoPs are maintained by face-to-face interaction to build trust and to know whom in the community they can consult for guidance or advice (Amin and Roberts, 2008; Brown and Duguid, 1998; Wenger, 2000). Knowledge is primarily shared face-to-face but abstractions like shared tools, symbols, concepts and terms also play an important role in storing and conveying knowledge more broadly within the community, albeit in reified form (Wenger, 1998). Interactions in CoPs are informal but also function to carry status information. Interactions typically comprise impromptu conversations and brainstorming (Roberts, 2006); raising questions, highlighting problems, offering solutions, posing answers, laughing at mistakes and discussing the organisation (Brown and Duguid, 1991). Being valued and gaining status within the community rests on displaying competence – usually through sharing 'war stories' about particularly difficult repairs, or by being able to advise other practitioners (Orr, 1996). CoP norms also typically emphasise this definition of value – while mistakes are tolerated, laziness is not (Orr, 1996).

CoPs, by their very nature, are emergent – they cannot be created by managerial fiat (Sandiford and Seymour, 2007). Moreover, the workers who form these communities tend to

associate horizontally, avoiding the status groups above and below them (Sandiford and Seymour, 2007). Formal organisational contexts do have a bearing on CoP formation; organisations can create good or poor conditions for CoPs to emerge. In contexts where the workforce is fragmented, dispersed and under pressure it cannot be assumed that CoPs will still provide a means of developing and sharing skills (Grugulis and Stoyanova, 2011).

A generally overlooked feature of the CoP is the pleasure that is derived from membership and the influence this can have on behaviour. Socialising and shared problem solving are themselves a source of pleasure for repair workers (Orr, 1996). CoPs are also an important basis for giving shared identity and meaning to individuals at work - so much so that members may well make an effort to continue the life of the CoP, even after its original source, the workplace, has closed down (Mackenzie et al., 2006). A CoP, is thus, for its members, an end in itself, something to be preserved for its own sake. This is an important characteristic of CoPs, one that, in part, this article argues, conditions behaviour in response to technology change.

The role of technology in repair work

The nature of repair work itself has two key implications for technology change. Firstly, repair work, because of its variability, is difficult to routinize through technology. Secondly, the high levels of skill, tacit and formal knowledge required to do the job, along with time and physical spaces needed to informally share knowledge make the workforce relatively expensive and, therefore, paradoxically, attractive to management as a source of cost-saving through the introduction of technology that will capture that knowledge. In many respects, the history of repair work, and of its CoP, is the history of attempts to routinize work and

reduce reliance on expensive workers. Beck's (1992) term, 'individualisation', sums up the direction of technological travel well. It is reasonable to assume that skilled repair workers form a special category of worker for whom routinisation via technology is and has been an ongoing objective of management. The present study, by default, is an addition to that history and up-dating of it, in light of rapidly improving technology.

We also note that the introduction of technology to the work of repair engineers tends to fall into two distinct categories. The first is the introduction of communication technologies that allow repair workers to interact more easily with each other and with management, control and dispatch centres. This has included radios (Orr, 1996), information communication technologies (ICTs) (Wenger, McDermott and Snyder, 2002) and latterly mobile phones (this study). The second type of technologies are those that directly support their work, including manuals (paper and electronic) and, the subject of this paper, mobile knowledge-based diagnostics. The latter has only become viable for mobile workers relatively recently, with the eventuality of portable and powerful lap-tops and tablets – hence it has not been studied before. The empirical section describes the role of both types of technology over the period from the mid-1990s to the present.

While nothing has been written on the role of mobile communications among repair workers, much has been written about previous generations of supporting technologies. Orr (1996), for example, in his seminal ethnography on photocopy repairmen, makes much of the repair manuals used by his technicians. Critically, however, Orr observes that manuals provided were limited in their usefulness. The history of technology aimed at replacing worker knowledge, is also a history of technology failures (see for, example Brown and Duguid, 1991, 1998, 2000, 2001; Orr, 1996; Heath and Luff, 1996; Brady and Davies, 2010; Heath et

al., 2000) of which much has been made. The manuals, Orr notes, could never account for all possible repair eventualities and consequently and while he found that the technicians used the documentation routinely, they did not use it with the 'blind faith intended by its designers' (p.113). Another important system, aimed at capturing photocopy repair technicians' knowledge, the Eureka repair database created at Xerox, replicated these problems. The system was developed as a means of capturing and disseminating all of the knowledge needed to conduct photocopy repairs (Brown and Duguid, 2000; Cox 2007). However, because it relied on interviewing engineers to collect repair knowledge, it captured only partial and disembodied knowledge which, according to Cox, lacked the contextual richness needed to be an effective guide.

Technology, it is noted, can also have a negative effect on the conduct of repair work. Brown and Duguid (2001) also noted that the 'formality' of working practices demanded by technologies (they are referring to the growing use at the time of ICTs) can have the effect of disrupting the informal relations that CoPs rely upon. New technologies, they note, might break CoP collectives down, dispersing them, potentially, into competing individuals (Brown and Duguid, 1998: 92). Although their work does not actually explore this thesis this is an issue we pick up in this. Nonetheless, it is important to think, argue Brown and Duguid (1991) in terms of 'both/and', rather than simply 'either/or'. In other words, they argue, it does not need to be a case of technology at the expense of the CoP or that the CoP cannot function productively *with* technology.

Overview of Data Collection

The research investigated a particular 'GasCo' (not the company's real name) geographical territory, referred hereafter as a 'patch', located in the North East of England. Data was collected

in three phases between (1) April and August 2010, (2) May and June 2011 and (3) January and April 2012. The research design was discussed and planned with regional and local management at GasCo to secure approval. Full access was granted to the everyday work of repair engineers, or Technical Engineers (TEs) as they were referred to. Data-collection comprised twenty-six in-depth open-ended interviews with a purposive sample of TEs and Middle managers and fifty hours of observation. This allowed proximity to the TEs everyday work practices, while also enabling the capture of rich and detailed empirical data.

[Insert list of interviewees here]

As the research took place over an extended period the researchers feel confident that trust and rapport was built up between researchers and the TEs. The absence of a physical work place other than in the TE's vehicles, meant the vast majority of interviews took place away from the organisation in neutral social settings. TEs were candid in their replies, having been assured that their real names would not be used. It was also made clear that interest was in the TEs experience with the technology not issues like efficiency, which would have signalled an alignment with management interests. The researchers are confident, therefore, that the results were not skewed by management sanctioning the research.

Each interview was guided by an *aide memoir*. Topics explored included: the experience of work, experiences of technology, organisational change, interactions and relationships with colleagues and managers. Interviews typically lasted between 1 and 1.5 hours were audio-recorded by dictaphone and subsequently transcribed verbatim for coding and analysis. Interviews are considered a highly efficient way to gather rich, detailed and intensive empirical data (Eisenhardt & Graeber, 2007). Conducting interviews assumes that one can understand 'how the world is known by asking informants to answer questions about their experiences'

(Siggelkow, 2007). Data was also gathered from observations of two team-brief meetings, two technical, operational and safety meetings, formal and informal interactions at the patch collection point, informal interactions at a social after-work event and the shadowing of one engineer. Field notes were taken during each observational session and served an important role in connecting the researchers with the participants in the writing up of the research (Wolfinger, 2002).

Organisational and technological change at Gasco

GasCo has increasingly diversified in recent years. Alongside providing gas and electricity, the company installs and services central heating and household appliances in millions of UK homes. Knowledge, workforce quality and cutting-edge supporting technology is pivotal to their competitive advantage and their status as a market leader. The organisation employs over 20,000 people of which 8,000 are Technical Engineers. TEs generally work alone servicing and repairing domestic gas boilers and central heating systems. At the time of the study the firm had been undergoing a cultural transformation toward a more commercial 'sales' focus. This was most notably expressed through a financial reward scheme for achieving time efficiency and 'Best Advice' where TEs could earn individual and team bonuses for high performance. 'Best Advice' was a company pseudonym for selling such things as product upgrades to customers.

The company was also seeking efficiencies through digital technologies, diagnostics and changes to how TEs were managed. Digital technologies were also becoming more central to how managers managed - with real time performance data and monitoring becoming

available. Performance in this respect was closely monitored, TEs being required to record and upload their activities to a Management Information System, in real time. Managers could easily rank TEs according to performance on different measures, and did so – encouraging individualisation and competition, rather than collectivism and community.

The laptops, on which the diagnostic software would eventually be run, were originally introduced in 1997 as the first move in this transformation. Originally a more convenient vehicle for carrying manufacturer's manuals, improved internet connectivity meant that the laptops also became a means by which TEs could receive daily job allocations at home. Prior to this the TEs would gather in the morning at the company depot where they could buy food and drink and would spend time waiting for jobs to come in. Time would be spent 'bantering' about challenging repairs, much the same as Orr's (1996) technicians' had done. The introduction of the laptops, along with connectivity, weakened the case for keeping the depots open. TEs subsequently spent more time in the field working, which was an efficiency gain, but also more time in isolation from colleagues in their community. The company-owned depots were discontinued over time and replaced with leased collection points (CPs). Rather than 'hanging about', the TEs were expected to make only brief visits to 'talk to their managers and collect ordered parts'.

“There used to be depots you used to go in the morning at 8am and never left till 9am because you went in the office and then the stores and chatted a bit and it was more because you were there every single day and no-one was chasing you out of the door it's just the way it was, mind you the laughs we used to have and we used to have much more. We'd go out a lot more often as a group because you got to know each

more. You're spending 5 hours a week, in the mornings chatting so it used to be great. Course it's all about money now, sitting there doing nothing it's not cost effective for them. Before it used to set you up for the day and now they're chasing you out the door". (Richard, Engineer, 25+ years experience).

Further supporting this shift toward more field time was XTECH. XTECH, introduced in 2003, is a laptop-based diagnostic system that identifies faults systematically by 'walking' the TEs through a series of yes/no questions. The software was introduced to increase the efficiency of repairs and to allow TEs to work more independently and with less ongoing training. Like all knowledge-based systems it seeks, in effect, to replace the knowledge held by the individual and the community. However, the program represented an improvement over the more top-down systems characterised in the literature. Unlike previous repair work support systems, it was notable that XTECH was produced in a way that actually reflected how repair work was done in practice. Designers developed the system's decision trees in an emergent fashion - by creating faults in existing boilers, resolving them and then mapping the results. Systems are normally developed by first mapping reified versions of work flow processes, work as it would be done without the unexpected demands that 'real work' invariably throws up, and then building the systems around that. As noted, this reified version of work is then typically re-imposed on the workforce, often with disappointing results. XTECH was still far from perfect, but what it did achieve through this process was an authenticity which top-down systems usually lack. This point is discussed later in the article.

XTECH also possessed a 'hints and tips' database made up of observations posted anonymously by TEs and a notes section that allowed TEs to record observations on repairs

done on each boiler - thus each boiler contained its own narrative on previous repairs. A point also returned to later in the article.

Management's view of XTECH

The patch line-managers (there were two) and regional operations manager, it was found, were well disposed toward XTECH, describing it as more than sufficient to support the work that the TE's did. All of the managers were former TEs and their main role was to support the TEs in the field:

“...in the past, when I qualified, it was a lot more you needed to know about the boiler, but now this thing [insinuates laptop/XTECH] almost carries you through and, as long as you follow it, the likelihood is that you will get it right, which I think is absolutely brilliant” (Alex, Manager, mid-50s, 30+ years experience)

“We could take, for example, either of you [researchers] right off the street, if you've got the right attitude and you want to learn and we could say right we're going to put you through this training academy and you're going to do your training and it's a bit hands on, but you would come out and know enough about the basics to go to that boiler to say right ok I'm qualified to do it... I think it [XTECH] is absolutely brilliant. (Ed, Manager, early-50s, 25+ years experience)

Arguably, the availability of the diagnostics and other technologies, and the belief of the managers in them, put an upward pressure on performance expectations – or at least provided grounds for strong rhetoric around disciplining poor performance:

“...with an individual I will show them - here is our team and you are at the bottom, how do you feel about that? There is not one engineer who I know who would say

‘I’m not bothered’. They do care and it matters how they are perceived. With everything they have to help them do their job there is no reason why everyone can’t do it”. (Frank, Manager, late-30s, 10-15 years experience)

Such was the perceived effectiveness of the technology, in the minds of managers, that underperformance was regarded as a thing of the past.

TE’s view of XTECH

Surprisingly, despite the obvious potential for both surveillance and de-skilling inherent in the technology (an internet-enabled laptop in combination with a knowledge-based system aimed at replicating the TEs knowledge), it was found that both XTECH and the laptops were well liked by the TEs:

“I love it when XTECH is there, literally if you’ve got a repair and you’ve got XTECH there you’re pretty confident you can either fix it or diagnose it. Even if it doesn’t come up with the right answer it can push you in the right direction and make you think ‘ah it’s something else”. (Adam, Engineer, mid-40s, 1 year experience)

“Before I developed my knowledge and experience the laptop and its software XTECH was especially useful. The diagnostic software is so systematic and when you don’t have experience of that systematic procedure it becomes beneficial to you - so that then you don’t need XTECH because you are using that same systematic approach on everything you work on”. (Mike, Engineer, mid-30s, 7 years experience)

This lack of resistance to XTECH can be explained by some key features of the technology. Firstly, it is highly flexible, allowing technicians to ‘jump-in’ at any point in the diagnostic process to test their own hypotheses. This means that it does not have the debilitating effects that more directive technology can have. Secondly, the technology was also good at delivering some of the rich context that systems in the past had not:

“There is a fourth tab called ‘other’ which is the job history telling you what the previous engineer did. Actually if it is a breakdown I will always check the job history first. You can see what has been done what parts have been changed and it can help narrow down the fault or identify if there has been a recurring fault. Check who has been there because there can be certain things with certain engineers that can tell you something. Some of them are a bit lazier than other ones and some are better than others. There are ones who get loads of recalls.” (Mike, Engineer, 7+ years experience)

Finally, the technicians also appeared to respect the knowledge captured in the system. This stemmed, it is believed, from the fact that it was built by designers going through the same fault finding processes that the TEs themselves go through – giving it a tacit content and authenticity that made it more palatable and practical to use. A similar acceptance is noted by pilots of cockpit checklists – these are also produced and augmented by professionals they regard as members of their own community (Gawade, 2010).

This article is thus slightly at odds with Brown and Duguid (1990). The conflict they perceive between canonical and non-canonical work (work as envisaged by managers and expressed in manuals and work as it is actually done) is, with good design processes, potentially reducible.

In this case, the reified canonical version is produced using the same practices that the TEs use. When this occurs some of the tacit knowing about how work is done is built into the formulaic (canonical) version. Such tacit knowledge would comprise, for example, how long each step can sensibly be and how much prior knowledge it should assume. Such systems will also have a semiotic component – they will look and feel ‘authentic’.

Another key feature of the system, one which went hand in hand with its inherent flexibility, was that it was not always right.

“There are errors...you might get XTECH saying it’s the PCB and the manufacturer’s manual saying a fan. So it’s not flawless...there is always another little branch that can be added”. (Adam, Engineer, mid-40s)

“Well the most useful tool is probably (points to head)...but (nevertheless) there are a lot of tools at our disposal, our phones, the laptop, technical helpline, manufacturers helpline...(and there is) hints and tips...which saves us from ringing others and it’s making use of our (own) experience and knowledge”. (Richard, Engineer, late-40s)

The view that the TEs knowledge remained central to the job was also confirmed by the same managers who had had much praise for engineers:

“Dave is the Isar whisperer – he has one himself and it’s one of the first ones. He tinkers and keeps a stock of spares. So if one of the guys has a problem with an Isar they call [Dave] and he can usually work out what is wrong straight away. We’ve got [Mike] who does all the long duration work so with any system fault where say a boiler

may be pumping over and [Mike] can say it'll be this – he knows because he's seen it all. [Derek] is pretty good on Worcester's so the lads all know that and will either book those jobs to him or ask him for advice". (Walter, Manager, mid-30s, 8+years experience)

Thus, slavishly following the path dictated by XTECH did not always solve the fault and rapid problem solving lay in 'knowing' a particular boiler and its idiosyncrasies, or knowing someone who did. There was no doubt that, in conjunction with other technologies, the diagnostics reduced reliance on training, experience and community interaction, but it had not yet entirely dispensed with it. Consequently, while useful to the TEs, particularly newly trained ones, it was not able to completely capture the knowledge required to fix boilers and so simultaneously de-skill the TEs. It followed from this, that the TEs viewed XTECH as an adjunct to their own knowledge not a replacement for it. The system's flexibility contributed to this sense – e.g. being able to 'jump in' where they chose – so leaving the engineers a degree of autonomy. The pleasure of working with machines is dependent upon them demanding a certain level of skill and knowledge, and therein, autonomy (Wajcman, 2006; McCarthy and Wright, 2004).

In a sense, XTECH had failed to squeeze that autonomy out of the TEs role and it was more readily accepted by them as a consequence of that. While managers grumbled about TEs not following the steps as laid out in XTECH, it was, nevertheless, a practice accepted by them. Faith in the technology coexisted in the minds of managers with an acceptance of the need for individual and community knowledge. Here again findings are at odds with Brown and Duguid (1990), and indeed Orr (1996), all of whom perceived a greater distance between the

worlds of managers and technicians than was found in this study. In their accounts, non-prescribed practice was viewed 'through the corporation's eyes' as 'deviance' (Brown and Duguid, 1990, p. 42); whereas a tolerated necessity for getting the job done was found in this study.

Post script -Maintaining the Community of Practice

The technician's CoP, for a variety of reasons as noted, seemed well able to absorb XTECH with relatively little obvious change. However, the enrolment of XTECH as part of a strategic narrative about efficiency helped to support broader moves toward individualisation by, in effect, promising to de-risk them. The hubris surrounding the technology as a total solution to boiler repairs, in the face of evidence that it was not, is part of this. The closing of the depots, scheduling work from home and XTECH, were all part of the same strategic drive in GasCo. However, TEs were not passive in the face of this undermining of their community. By 2010 personal mobile phones had become common place among the TEs and this technology offer a means for TEs to re-connect their community. Orr (1996) had suggested the use of hand-held radios for knowledge exchange; however, his study of photocopier engineers had ended before the idea could be implemented. The TEs at GasCo had previously been given radios, but they could only talk to other TEs by being routed through 'base' – which could handle only one call at a time. The radios were for allocating 'jobs' and keeping track of TEs, not for sharing knowledge about repairs. Mobile phones extended the functionality of the radios by allowing person-to-person communication that could not be monitored by management or indeed the rest of the community. Mobile phones re-facilitated knowledge flows between TEs and even served to maintain some face-to-face interaction by facilitating 'meets' in local cafes for breaks or lunch and after work gatherings in a local pub. Consequently, mobile phones came to play

a key role in facilitating the continuation of the CoP. Indeed, their role in this guise could be powerful:

“I leave my phone on 24/7, I don’t mind the lads phoning me up even on my day off, it doesn’t bother me, but if they don’t phone I cannot help them” (Derek, Engineer, mid-50s, 30+ years experience)

Like XTECH, mobile phones were quickly woven into practice, the flow of knowledge *and* the sense of being part of a community were both facilitated through them. However, the introduction of mobile phones into the CoP, also subtly changed it. Critically, it was found that phones encouraged TEs, together it is suspected with the pressure to perform, to work together in smaller and smaller groups. The very nature of the technology, in that it facilitates one-to-one communication, encourages working in smaller trust-based groups.

“Everyone has a few people they phone so that if there is a problem they can ask if they have come across this or ask for suggestions” (Nigel, Engineer, mid-40s, 3+ years experience)

“Derek and Mike we’ll work round each other –they’ll come to me and I’ll go to them. Usually it’s this little triangle that tends to work together around jobs and this seems to work well for us...we try and stick to the three of us” (Richard, Engineer, mid-50s, 25+ years experience)

It was also clear that the nature of phone interactions were quite different from the more expansive banter of face-to-face interactions. The following is taken from field notes:

...the phone calls to other engineers are all about explaining and resolving the problem/repair as quickly and concisely as possible. They all appreciate the time pressure everyone is under. There is no time to talk about issues that are not directly relevant to the repair/problem at hand, i.e. grumpy customer etc.

Reliance on mobile phones also introduced other issues for the functioning of the CoP. The use of phones requires a certain level and type of sociability that not all TEs possessed. In particular, some TEs were perceived to be nervous about asking for help using their phones:

“A lot of the young lads I feel sorry for because if they haven’t got the confidence to phone people up, they are going to struggle because they don’t basically see anybody from one day to the next, because they are getting chased out of the collection points in the morning and it’s put them under immense strain”. (Derek, Engineer, mid-50s, 30+ years experience).

Not being comfortable calling other technicians was thus a potential issue for some. Shifts towards mobile communications, rather than face-to-face contact, builds requirements for social skills that some TEs, whatever their technical abilities, may lack. Thus, if TEs do not have the social skills, or luck, to be able to link into an effective team, their own effectiveness will suffer. Combined with an increased technology-based ability to monitor TEs performance, the potential for stress and ‘burn-out’ was obviously high. GasCo was in danger of losing perfectly capable engineers who had simply been unlucky enough not to find

themselves part of effective knowledge-sharing groups. While in the short-term the phones fixed the problem of a lack of face-to-face contact, in the longer term phones were helping to instantiate a new organisational structure around smaller more exclusive groups and individual experts like 'Dave'. It was, thus, unclear whether the CoP would survive this emergent, self-restructuring. It was also clear also, that the new generation of TEs, if they were prevented from accessing the CoP, would most likely see the CoP flounder with the retirement of the existing, older, established TEs.

Discussion

Implications of CoPs for the Shaping of Workplace Technology

CoPs play an important role in mediating the impacts of technology on skilled workers. Central to their effect in this regard, is that membership of a CoP is, from the perspective of the worker at least, a desirable end in itself. Workers do not wish to be subject to control through technology and management, but through their peers. As such, it is to be expected that individuals in CoPs will respond to technologies that threaten horizontal peer linkages, while emphasising management control, by seeking to work around them. Workers will find ways, in other words, to maintain communication and social interaction with their peers in order to sustain the CoP.

It was evident that the mobile phone, or rather the use to which it was put in the CoP, was shaped by this desire; to repair the damage done to the CoP and to remain individually competitive. The role of the CoP can be seen again in the way in which some aspects of XTECH were 'mis-used' by the TEs. The use of repair histories by TEs to make judgements about colleague's reliability and to help reach early conclusions about faults, was particularly interesting. Knowledge about individual reliability fed into judgements about boiler repairs,

the reality of which (i.e. the actual problem) fed back again into judgements about individual reliability. This is precisely the sort of contextual knowledge that helps the CoPs function - supplied inadvertently by XTECH. While the managers interviewed frowned on the use of 'hints and tips' to aid repairs, they tolerated it nevertheless. In this instance, a little deviance was tolerated because it met other organisational objectives – quick repairs.

The CoPs perhaps played a weaker role in influencing the rate and extent to which XTECH was taken up by the TEs. Here, despite the threat posed to the CoP by the technology, the technology was nevertheless unproblematically adopted into practice. Although XTECH was a threat to the community, this was not obvious at the individual level. Moreover, at the level of the individual, the technology was experienced as a positive addition to their technological problem-solving 'armoury' - it made their jobs easier but not, in the short term, less enjoyable. It was experienced, for now at least, as an adjunct to their work, not as the master of it. Thus, XTECH occupied a middle ground between supporting and de-skilling work. It disciplined practice by encouraging a more structured approach to problem solving, but did not remove the autonomy necessary to properly de-skill it.

It can be surmised from this that the CoPs can fail to generate, amongst members, a sense of their common longer-term interests. CoP members can act individually, and inadvertently, at the expense of the CoP. Thus, technology that can offer short-term gains to the individual will always find acceptance - even if its long-term consequences are to undermine collective interests. This is perhaps why the durable materiality of technology will always, in the long-run, trump the power of the social to resist and shape it. While the CoP does have effects on how technology is used – these effects are limited by the extent to which they map onto individual perceived interests. The CoP generates individual interests by being an end in itself – but it lacks the foresight that more formal decision making organising might provide. It is, ironically, too emergent to be an effective source of resistance to technology change.

The article also highlights the importance of assessing the capabilities of technology in relation to their likely impacts on CoPs. The analysis of technology, from a social shaping perspective, needs to be able to say why a technology is effective, not just why it is not. In terms of its own design aims, XTECH was not entirely a success. It failed to offer a reliable and comprehensive replacement of the knowledge held by the Gasco TEs. The TE's still needed to consult one another. This did not render it useless, however. It remained a useful adjunct to the TEs work and an improvement on previous attempts to provide supportive workplace technology to repair engineers. Indeed, this article has argued, TE's appeared to accept XTECH all the more readily because it did not de-skill them. This acceptance was further aided by the fact that XTECH was designed in a way that reflected actual practice; achieved by placing the designers in the same problem-solving context that the TEs faced. Creating codified knowledge in this way produces interfaces that are recognisable and so authentic to the end user. The knowledge behind the interface is still reified, but it accords with and reflects the practice norms of the community. Analogies for this can be found, as noted, in pilot's checklists. The notion of authenticity, with respect to a Community of Practice, is an important but over-looked aspect of the acceptance of technology. Following from this, it is also suggested that three aspects of a technology must be in place for it to find acceptance within an existing community of practice: It must not *obviously* threaten the functioning of the CoP; it must serve the perceived interests of individual CoP members and it must appear authentic in relation to existing practice.

The implications of technology for CoPs

The impacts of technology on the CoP were more than just physical, they were also rhetorical. XTECH, while not successful at replacing TE knowledge, was nevertheless still

part of a powerful organisational narrative aimed at removing reliance on the CoP. While the closure of the depots was directly facilitated by internet enabled laptops, XTECH played a more oblique role in their closure, by giving substance to the strategic narrative that an organisation of skilled, knowledge-dependent individuals can be sustained by information technology alone. The existence of the technology, whether it actually worked or not, made the closure of the depots and the instigation of policies driving work intensification, primarily keeping TEs out in the field, more tenable. This helps explain the need for managers to sustain the contradiction between praise for the TE's knowledge and praise for XTECH as a total solution. As the strategy was being implemented regardless, it was essential that they expressed confidence in the technology, both to this research and, it is assumed, to the TEs. Paradoxically, mobile phones, while characterised in the literature as highly flexible, had a stronger direct effect on the CoP. By their very nature, mobile phones facilitate one-to-one interaction more easily than group interaction – as a consequence they encourage person to person use and, therefore, interaction with more limited numbers of community members. The phones, thus, supported the CoP while at the same time encouraging its fragmentation into sub-groups. Insular knowledge-sharing groups corralled knowledge and risked isolating newer, less established, engineers or those lacking the social skills to engage.

Conclusion - The future for CoPs

The future for CoPs, in the face of increasingly well-designed information technology appears bleak. While CoPs are far from unresponsive or powerless constructs, waves of technology change aimed at removing the fundamental organisational conditions needed to sustain them, look likely to simply erode them away. To firm owners and managers, the conditions needed to sustain traditional CoPs (physical places to meet and time to interact, as

a minimum) are un-productive slack than needs to be chased out of the organisation. It was clear from the nature of the technology and discussions with management that XTECH was aimed squarely at reducing the dependence of individual TEs on the CoP and indeed on their own skills and knowledge. The laptops began the processes of breaking up the CoP and XTECH was a logical step in the same direction. Ironically, the actual ability of technology to fully replace CoPs appeared less important than the managerial *belief* that it could.

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Table 1 Interviewee Profile

Name	Role	Years Experience	Number of Interviews	Date	Location
Mike	Engineer	5-10	3	April 2010, April 2011 and May 2012	Home, Collection Point, Public House
Nigel	Engineer	2-5	1	May 2010	Café
Richard	Engineer	25+	1	June 2010	Café
Walter	Manager	5-10	2	May 2010 and April 2012	Café, Hotel
Ed	Manager	25+	1	June 2010	Restaurant
Derek	Engineer	25+	2	June 2010 and April 2012	Café
James	Engineer	2-5	2	May 2010, April 2012	Vehicle, Home
Robert	Engineer	2-5	1	June 2010	Cafe
Jason	Engineer	5-10	1	May 2011	Public House
Sam	Engineer	20-25	1	May 2011	Public House
Michael	Engineer	2-5	1	May 2011	Public House