Introduction

While Technology Enhanced learning (TEL) has been suggested as a means to address the challenge of supporting learning at the workplace, its potential has not yet been fully realized. Especially in many Small and Medium Enterprises (SMEs), the take-up has not been effective. A critical review of the way information technologies are being used for workplace learning (Kraiger, 2008) concludes that still today most solutions are targeted towards a learning model based on the ideas of direct instruction in a more or less formal manner. TEL initiatives tend to be based upon a traditional business training model with modules, lectures and seminars transferred from face to face interactions to onscreen interactions, but retaining the standard tutor/student relationship and the reliance on formal and to some extent standardized course material and curricula.

However research suggests that (not only) in SMEs much learning takes place in the workplace and through work processes, is multi episodic, is often informal, is problem based and takes place on a just in time basis (Hart, 2011). Rather than a reliance on formal or designated trainers, much training and learning involves the passing on of skills and knowledge from skilled workers (Attwell and Baumgartl, 2009). In other words, learning is highly individualized and heavily integrated with contextual work practices.

In the past few years, emerging technologies (such as mobile devices or social networks) have rapidly spread into all areas of our life. However, while employees in SMEs increasingly use these technologies for private purposes as well as for informal learning, enterprises have not generally recognized the personal use of technologies as effectively supporting informal learning. As a consequence, the use of these emerging technologies has not been systematically taken up as a sustainable learning strategy that is integrated with other forms of learning at the workplace.

This paper describes the emerging results from the Learning Layers project, a large scale EU IST programme funded project which aims to scale up the use of technology for informal learning in the workplace. The Learning Layers project is researching the use of technology for learning in two 'clusters'; a medical cluster in north east England and the construction cluster in north Germany. The project is encouraging the use of existing technologies, especially mobile technologies for learning, whilst developing a design process to develop new apps and developing an infrastructure layer to support the integration of technology.
Our initial research in the healthcare and construction sectors has revealed a widespread interest in using mobile technologies for learning in the workplace, and in some cases considerable use of existing tools and applications.

However it has drawn attention to a number of critical issues, particularly in designing applications and approaches to informal learning for up-scaling to significant numbers of users (which is the overall aim of the project).

These relate particularly to an understanding of the nature of learning and the application of knowledge in the workplace, to interactions with 'real' artefacts and to the way new knowledge is developed and shared within and between organisations. Some of these issues are explored in this paper, which concludes with an examination of models and processes for user engagement.

Learning from practice

One of the major problems with Technology Enhanced Mobile Learning has been the split between the digital and analogue worlds. The digital world enables all kinds of personal interactions and interactions with digital artefacts. Some things are easier to digitalise than others. So books, diagrammes, audio, video can all easily be transmitted through digital media. But some artefacts – and, even more important: their use – are more difficult to capture

in digital media – for instance a hammer, a saw, an earthmover. Of course it is possible to simulate some of the interaction with 'hard' matter – for instance flying an aircraft.

It is much more problematic to capture the haptics of using a hammer. This is one of the main reasons Technology Enhanced Learning has tended to focus on cognitive processes of learning, although many areas of work require real world interactions with both people and with physical artefacts. The second reason is a one-sided idea of learning, focusing on processes of information gathering and information management and neglecting the importance of incorporated and tacit knowledge (Polanyi 1966) and the possibilities of its development. So, when it comes to practice we tell learners they should use their computers to assist in the process of reflection. That is fine but it is not enough.

The importance of tools and physical artefacts should not be underestimated. Artefacts are closely linked to practice. Wenger (1998) points out that, amongst other features, a Community of Practice is defined by "what capability it has produced – the shared repertoire of communal resources (routines, sensibilities, artefacts, vocabulary, styles, etc.) that members have developed over time."

There are different approaches we can take to integrating physical artefacts with applications and technology for learning including the use of QR codes and AR technologies. There is also much research into the use of wearable computers, and this field is like to become more important with the release of Google Glass. Indeed the major impact of such emerging technologies in education and training may well be in the field of work based learning, if these devices are able to fulfil the promise of allowing to capture and transmit work experiences..

At a more abstract level there is the need to progress beyond seeing technology (like Learning Management Systems) as a container for learning into using mobile technologies as a tool for working and learning. In other words mobile technologies themselves become an artefact, on the same level as other work tools, as for ex-

ample in the world of work of todays' skilled car mechatronics. These people have to be able to use and interpret computer generated data as well as having an understanding of the functioning o a modern car with its interplay of electronics and mechanics. There is also a need to integrate learning with the increasingly sophisticated data that many machines and artefacts produce – data that at the moment often exists in a silo. This means integrating learning in the work process, and bringing together digital work tools with digital learning tools. That learning needs to be scaffolded seems obvious. But the scaffolding should move seamlessly between the use of digital devices and interactions with real life objects – as it already does in the world of work, too. The work of specialised electro-technicians for example more and more involves installing as well as programming digital devices. Enhancing informal learning by technology may help to make processes of informal learning explicit and easy their recognition. It can help to transform work experiences into learning material and work objects into learning objects.

Informal Learning, Communities of Practice and Situated Learning

The Learning layers project is focused on informal learning. Whilst this recognises that most learning takes place outside the classroom and outside the sphere of formal education or training, the distinction between informal and formal learning is problematic, especially when it comes to technology enhanced learning. If an apprentice contacts an expert for advice using a mobile device is this formal or informal? Is watching a video – may it be the manufacturer's or even on YouTube to gain practical knowledge about a particular product or tool formal or informal learning? One way round this conundrum has been to view learning in terms of formal or nonformal settings. Yet if a construction worker undertakes an authentic work task in a training centre is that formal learning whilst undertaking the same task in a work place makes it informal? Once more this is problematic and especially so with the increased use of mobile technologies which link learning to practice. A better approach may be to view informal learning as an

expression of situated learning which takes place in a social environment.

Despite often espoused adherence to constructivist pedagogies, much of the development and theorizing concerning the use of technology for learning has treated cognition as being 'possessed and residing in the heads of individuals' (Salomon 1993: xii). This has limited its applicability to vocational learning, let alone work based or practice based learning. However the idea of distributed cognition is based on the tools and social relations 'outside' people's heads (Smith M.). They are not only 'sources of stimulation and guidance but are actually vehicles of thought… It is not just the "person-solo" who learns, but the "person-plus", the whole system of interrelated factors' (Salomon 1993.: xiii). People think in relationship with others when they use various tools and different cognitions will emerge in different situations.

Situated learning can be seen as involving participation in communities of practice. Such a community of practice typically evolves around a common domain of skills and knowledge, often organised as an occupational field. Skills and knowledge are developed in relation to this field.

According to Smith "Learning involves the whole person; it implies not only a relation to specific activities, but a relation to social communities – it implies becoming a full participant, a member, a kind of person. In this view, learning only partly – and often incidentally – implies becoming able to be involved in new activities, to perform new tasks and functions, to master new understandings. Activities, tasks, functions, and understandings do not exist in isolation; they are part of broader systems of relations in which they have meaning. (Lave and Wenger 1991: 53)"

Novices enter at the edge – their participation is on the periphery. Gradually their engagement deepens and becomes more complex. Knowledge is, thus, located in the community of practice. Furthermore, in this view 'it makes no sense to talk of knowledge that is decontextualized, abstract or general' (Tennant 1997: 77).

Four propositions are common to the range of perspectives that now come together under the banner of situated learning (Smith,):

1. High-level or expert knowledge and skill can be gained from everyday experiences at work, and in community or family.
2. Domain-specific knowledge is necessary for the development of expertise (i.e. much of expertise relies on detailed local knowledge of a workplace, locality or industry).
3. Learning is a social process.
4. Knowledge is embedded in practice and transformed through goal-directed behaviour. (Tennant 1999: 170).

Thus, the successful development of technology for work based learning must not only be embedded in work practices, but must also reflect the domain specific knowledge required for the development of expertise. It also has to reflect the goal of activities undertaken – both for working and learning - and to allow for social interaction in the learning process. The use of mobile technologies allows learning which is both situated in work practice and with communities and at the same time distributed within extended communities including work based and personal networks.

This has implications not only for the functionality and uses of applications for technology based applications for work based learning but for the design process itself. It is hard to envisage how applications can be developed to reflect the domain based knowledge which resides in Communities of Practice, without the involvement of skilled practitioners from that domain. For this reason the Learning Layers project has adopted a user centred design approach.

The nature of Communities of practice and situated learning, also impacts on strategies of upscaling the use of such technologies for learning. This will be explored later in the final section of this paper.

Different types of knowledge

When thinking about knowledge development in a richer way, it may be useful to distinguish between different types of knowledge. Lundvall and Johnson (1994) identify four different kinds of knowledge, each requiring different types of mastery: know-what, know-why, know-how, and know-who.

Know-what refers to knowledge about 'facts': it can be considered as equivalent to what is normally called information and related to the knowledge 'corpus' that each category of experts must possess. Know-why refers to scientific knowledge, influencing technological development and the pace and characteristics of its applications in industries of every kind. Also in this case, knowledge production and reproduction take place within organised processes, such as university teaching, scientific research, specialised personnel recruiting, and so on.

Know-how refers to skills - that is, the capabilities to do something in different contexts (e.g. judging the market prospects for a new product, operating a machine-tool, etc.). Of course know-how is typically a kind of knowledge developed at the individual level[1], but its importance is evident also if one considers the division of labour and degree of co-operation taking place within organisations and even at the inter-organisational level (for instance, the formation of industrial networks is largely due to the need for firms to be able to share and combine elements of know-how). Know-who is another kind of knowledge which is becoming increasingly important, referring to a mix of different kinds of skills, in particular the social skills, allowing the access and use of knowledge possessed by someone else.

Rauner et al. (2013) modified these categories in order to bring it in line with the ideas of situated learning and communities of practice, emphasising the role of work processes and the corresponding work process knowledge. The categories of know-what and know-how still refer to 'factual' knowledge and the ways of 'expressing' it in a work process. The third category, know-why, refers to why to carry out a specific task in a certain way (or, if more appropriate, in another). This modification is due to the insight, that work tasks as well as work processes in post-taylorist work organisations do not follow a logic of

[1] One may add, considering the argument of situated learning, that this knowledge as well as ist development is heavily shaped by the relevant community of practice.

right/wrong. Instead, a solution to a problem can be more or less adequate. This adequacy depends on a number of partly conflicting factors, One may programme the control of a car's motor giving different weight to factors like acceleration, fuel consumption, high speed, exhaust emissions, etc., according to the intended main use. An electrician may counsel his costumer on the design of a lighting system regarding costs, efficiency, ecological aspects, sustainability, ease of maintenance, etc., according to the end-users' ideas. This, then, has the consequence that vocational learning has to address all these three dimensions of knowledge as a whole. The 'reflective practitioner' (Schön 1983) is not someone reflecting on what he or she has done after work, using analogue or digital media. 'Reflection' is a category built in the expert solution of work tasks requiring a deep knowledge of the work process a given task is embedded in.

Each kind of knowledge is characterised by different channels through which learning takes place and can be supported in different ways using technologies. The easiest cases are those of know-what and know-why, that can be obtained through the typical channels of knowledge acquisition (watching videos, accessing data bases), while the other two categories are rooted primarily in practical experience and in terms of technology enhanced learning have been more problematic insofar as they require the availability of informal social channels. Apprenticeship is a fundamental channel for acquiring know-how knowledge: it represents the most important way for skilling new-comers in an organisation, but these protracted processes of learning by doing are also frequently the responsibility of those who are considered the experts in an organisation, capable of above-average performance. Technology can be used to bring together novices and experts Simulations can be used as shortcuts for reproducing the many aspects of the know-how acquisition available in real situations. Mobile technology can capture know-how in the application of knowledge within the workplace. Know-why can be facilitated by helping to make traceable the processes guiding expert workers' decision making. In general, this points to a use of digital media going far beyond the transmission of information.

Boundary Crossing, Boundary Objects and Innovation

Informal learning may be at its most powerful where there is innovation – in technology or in work practices. Innovation in turn appears to

take place at the boundaries between different practices requiring inter –organisational collaboration or the development of new competences for practice. If technology enhanced learning applications can support developments in boundary crossing they may have most chance of uptake for work based learning.

One particularly fruitful way of thinking about skills development at work is to look at the boundaries between different communities of employees within a workplace and the artefacts (documents, graphs, computer software) that are used to communicate between communities (Kent *et al*., 2007). Following the analysis of Bowker & Star (1999), "boundary objects" are "objects that both inhabit several communities of practice and satisfy the informational requirements of each of them", thus making possible productive communication and "boundary crossing" of knowledge. In a project on knowledge maturing and organisational performance (Brown, 2010) an approach to learning based on the design of symbolic boundary objects which were intended to act as a facilitator of communication across community boundaries, between teams and specialists or experts was developed. Effective learning could follow from engagement in authentic activities that embedded models which were made more visible and manipulable through interactive software tools. In bringing the idea of boundary objects to the present research, it was realised that a sub-set of general boundary objects could be 'TEBOs' (technology-enhanced boundary objects), resources within an organisational learning environment which were software based.

This approach makes use of the notions of boundary object and boundary crossing. The ideas of boundary crossing and tool mediation (Tuomi-Gröhn & Engeström, 2003; Kaptelinin & Miettinen 2005) and situated learning with a close alignment to the importance of a focus upon practice (Brown *et al*., 1989; Hall, 1996) informed considerations of the role of technologically-enhanced boundary objects in knowledge maturing processes in different contexts. One specific concern is to make visible the epistemological role of symbolic boundary objects in situations in which people from different communities use common artefacts in communication. A fruitful approach to choosing

ways to develop particular boundary objects is to focus on what Onstenk (1997) defines as core problems: the problems and dilemmas that are central to the practice of an occupation that have significance both for individual and organisational performance.

Informal learning may be at its most powerful where there is innovation – in technology or in work practices. Innovation in turn appears to take place at the boundaries between different practices requiring inter –organisational collaboration or the development of new competences for practice. If technology enhanced learning applications can support developments in boundary crossing they may have most chance of uptake for work based learning. Still, the organisation of work has a powerful influence at this point. One may shape the same work processes in terms of flat hierarchies and open digital architectures, aiming at exchange of knowledge or one may design them in a neo-taylorist way, aiming at a better flow of information while planning and control is done by the management. This, obviously, has consequences for scale and scope of learning by the use of digital devices.

Conclusions

Educational technology has made only a limited impact in Small and Medium Enterprises because it has imitated traditional business training models and approaches to learning. To some extent hat has been due to the difficulty in using ICT in many working environments. The increasing adoption of mobile technologies offers new opportunities for developing work based learning and for up-scaling the use of technologies in work environments. However in order to build upon this potential researchers and developers need to understand the nature of the work environment and the different forms of competence and knowledge and how such knowledge is developed and shared.
There is particular opportunities to develop support for learning around the shared repertoire of communal resources and artefacts in emergent Communities of Practice.
In considering strategies for up-scaling learning, it is valuable to consider the links between learning and innovation and the boundary crossing that takes place within innovation networks.

Through these processes learning can be embedded within changing work practices. However, this requires a move from viewing mobile devices as a container for learning to seeing them as an active work and learning tool In terms of designing work based learning, mobile devices become part of an interactive and changing work environment. For such devices to be used, they have to serve a function: helping to solve work tasks. As we witness the overall trend to flat hierarchies - shifting the processes of planning and work organisation (and the corresponding responsibilities) from the management back towards the actors – having reached even branches like the construction sector, this cannot be limited just to enable an easier flow of information. Instead, mobile devices have to try to address all the dimensions of know-what, know-how, and know-why: they have to enable skilled workers and learners to make informed choices between different possible ways of carrying out work tasks, too. This can be done by enabling to share work-related experiences as well as by making transparent the choices inherent in carrying out complex work tasks. Often, tools that are developed without considering specifities of work organisation and work processes fail to be taken up by the end users. This calls for a different notion of user involvement, too. Given the importance of domain knowledge, of communities of practice and of the holistic learning environment, co-design processes have to be developed involving multiple stakeholders including SME managers, trainers and end users.

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