Developing PLEs to support work practice based learning

Authors

Graham Attwell
graham10@mac.com
Pontydysgu,
United Kingdom

Lars Heinemann
lheine@uni-bremen.de

Ludger Deitmer
deitmer@uni-bremen.de

Pekka Kämäräinen
pkamar@uni-bremen.de
ITB, University Bremen,
Germany

The paper describes research and development of a mobile, work-based Personal Learning Environment being piloted in the construction and health sectors. It examines a number of critical issues, particularly: the nature of learning and the application of knowledge in the workplace, interactions with physical artefacts, and the way new knowledge is developed and shared within and between organisations. A mobile PLE needs to support the different dimensions of know-what, know-how, and know-why and to enable skilled workers and learners to make informed choices between different possible ways of carrying out work tasks. 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.

Instead of seeing mobile devices as containers for learning, the PLE is viewed as an active work and learning tool within a changing work environment. The aim is to develop PLEs which are embedded in the practice of both learning and working, which can bring together informal and formal learning and which can facilitate the development and transfer of knowledge, learning and innovation between different contexts and domains.

Tags

Work process knowledge, Personal Learning Environment, mobile devices, physical artefacts, knowledge sharing, mobile learning

1. Introduction

While Technology Enhanced learning (TEL), Personal Learning Environments (PLE) and the use of mobile devices have been suggested as means to address the challenge of supporting learning at the workplace, their potential has not yet been fully realized. Despite much theoretical research in the use of mobile devices for work-based learning, there are still few compelling examples of effective practice. While there are case studies of both mobile devices and PLEs supporting work-based learning, these tend to remain isolated with limitations on upscaling or wider adoption.

A critical review of the way information technologies are being used for workplace learning (Kraiger, 2008) concluded that most solutions are targeted towards a learning model based on the idea of direct instruction. TEL initiatives tend to be based upon a traditional business training model transferred from face to face interactions to onscreen interactions, but retaining the standard trainer / learner relationship and a reliance on formal, and to some extent, standardised course material and curricula.

However, research suggests that (not only) in Small and Medium Enterprises (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 (Attwell 2007; 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 and to a lesser extent for information seeking and informal learning, enterprises have not generally recognized the potential of such technologies for supporting learning. As a consequence, the use of these emerging technologies and support for Personal Learning Environments have not been systematically taken up as a sustainable learning strategy that is integrated with other forms of learning at the workplace.

2. The Learning Layers Project

This paper describes the emerging results from the Learning Layers project, a large-scale project funded by the EU IST programme, which aims to scale up the use of technology for informal learning in the workplace. The Learning Layers project is researching and developing the use of technology for learning in two 'clusters': a medical cluster in north-east England and a construction cluster in north Germany. The project is encouraging the use of existing technologies, especially mobile technologies for learning, whilst supporting 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. The flexibility of mobile apps facilitates the adoption of Personal Learning Environments (as has been previously shown by the EU ROLE project, albeit in more formalised learning contexts). However, our initial research 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 co-design and user engagement.

3. Learning from practice

One of the major problems with Technology Enhanced mobile Learning (and indeed with the use of other technologies for work based 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. Books, diagrams, audio, and video can all easily be transmitted through digital media. But some artefacts – and, even more importantly, their use – are more difficult to capture in digital media, for instance a hammer, a saw, or an earthmover. Of course it is possible to simulate some of the interaction with 'hard' matter – for example, 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 while neglecting the importance of incorporating 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 on real life learning. 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 Augmented Reality technologies. There is also a lot of research into the use of wearable computers, and this field is likely to become more important with the release of products such as 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 fulfill the promise of allowing the capture and transmission of 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 (as a work based PLE). In other words, mobile technologies themselves become an artefact, on the same level as other work tools.

There is also a need to integrate learning with the increasingly sophisticated data that many machines and artefacts produce. Car mechatronics have to be able to use and interpret computer generated data as well as have an understanding of the functioning of a modern car with its interplay of electronics and mechanics. However, in terms of learning, a lot of machine generated data often exists in a silo at present. This requires 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. The work of specialised electro-technicians, for example, increasingly involves installing as well as programming digital devices. Enhancing informal learning with technology may help to make processes of informal learning explicit and facilitate the recognition of such learning, especially with new forms of learning analytics. It could help to transform work experiences into learning material and work objects into learning objects.

4. Informal Learning, Communities of Practice and Situated Learning

The Learning Layers project is focused on informal learning. While 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 – produced by a manufacturer or published 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 non-formal 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 that takes place in a social environment.

Despite an 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). 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, 1995). 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). 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 (1992, 2008), "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)"

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, from this perspective, 'it makes no sense to talk of knowledge that is de-contextualized, abstract or general' (Tennant 1999). Four propositions are common to the range of perspectives that now come together under the banner of situated learning (Smith, 1999, 2008):

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).

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 and the development of a mobile PLE allow learning that is both situated in work practice and with communities and at the same time distributed within extended communities including professional and personal networks.

This has implications not only for the functionality and uses of technological applications for work based learning, but for the design process itself. It is hard to envisage how applications could be developed to reflect the domain-specific 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.

5. 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. It is 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, but its importance is also evident 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 or clusters 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, especiallysocial skills, allowing the access and use of knowledge possessed by someone else.

Rauner et al. (2013) further developed these categories to include 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 the reasoning for carrying out a specific task in a certain way (or, if more appropriate, in another).

Work tasks as well as work processes in post-Taylorist organisations do not follow a logic of right or 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 engine giving different weight to factors such as acceleration, fuel consumption, speed, exhaust emissions, etc., depending on how the car is to be used. An electrician may advise his or her customer on the design of a lighting system according to cost, efficiency, ecological impact, sustainability, ease of maintenance, etc., according to the end-user's ideas. This, then, has the consequence that vocational learning has to address all 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 process built into the expert solution of work tasks requiring a deep knowledge of the work process in which a task is embedded.

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, which can be obtained through the typical channels of knowledge acquisition (watching videos, accessing databases), while the other two categories are rooted primarily in practical experience. In terms of technology enhanced learning, these forms of knowledge have been more problematic insofar as they require access to informal social channels for learning. Apprenticeship is a fundamental channel for acquiring know-how knowledge: it represents the most important way for skilling newcomers in an organisation, but learning by doing requires access to occupational 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 many aspects of the know-how knowledge 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 designing a work based PLE this requires the use of digital media going far beyond the transmission of information.

6. Designing Work based PLEs: a co-design approach

In formal education settings, approaches to designing Technology Enhanced Learning (TEL), often based on instructional design, have tended to centre on a formal curriculum. Learners are provided access to learning materials including text and video with greater or lesser interactivity. The move towards PLEs has stressed the ability of learners to shape their own learning environment and has also placed greater emphasis on peer learning through personal learning networks, as seen in the cMOOCs. However, the emphasis on informal work-based learning and on developing different forms of knowledge based on holistic work tasks requires a different approach to design. The Learning Layers project has developed a co-design approach to developing mobile learning apps. Two Application Partner Days workshops – one in the health sector and the other in construction = brought together project partners with managers, trainers and practitioners from the two sectors. This was followed by a Design Conference where partners used paper based design processes to develop four initial design ideas (see Figure 1), around which design teams have been formed.

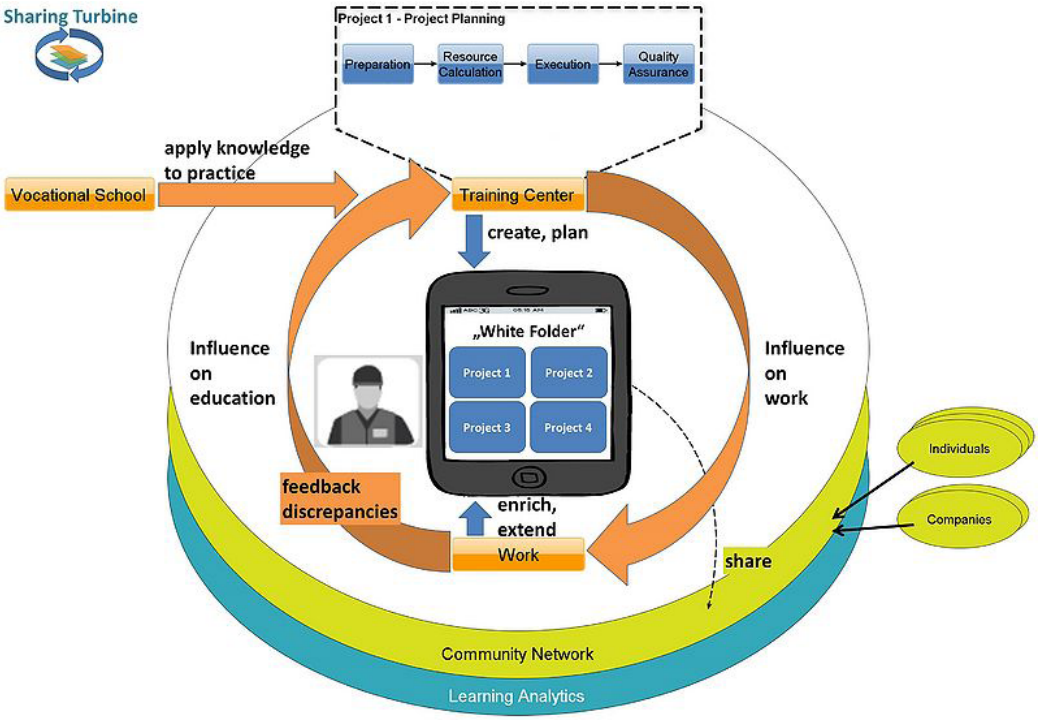

Figure 1. Sharing Turbine

This initial development work has been extended through the formation of local design teams in north-east England and in north Germany, once more bringing together project partners from research, technical development and the two sectors. Initial designs are being iteratively co-developed through a series of workshops. In the construction sector, there have been a series of expert workers workshops involving skilled and trained experts for the work processes they are engaged in. The workshops have explored the use and potential of existing apps for learning in the construction industry, looked at the use of different artefacts, developed pedagogic approaches to the design of applications, and provided iterative feedback on design work in progress. In the health cluster there has been a similar series of workshops held with primary care providers. A workshop held jointly with the UK National Health Service developers group, HANDI, brought together primary care providers, developers, trainers and researchers and allowed the project to gain feedback on the different design ideas. A variety of different methods have been used in the workshops, including paper prototyping and the development of wireframes (see Figure 2).

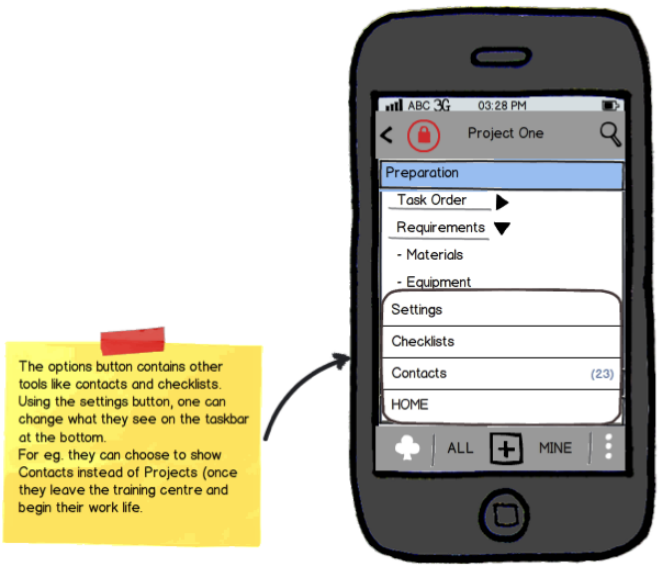

Figure 2. Wireframe for Sharing Turbine

The overall aim of this activity is to co-design a series of apps, which can form the basis of a mobile Personal Learning Environment. The apps can capture both formal and informal learning and link the learning undertaken in different contexts, including, in the German case, learning which takes place in the companies, vocational school and the industrial training centres. The apps are also intended to elicit interactive engagement with the environment and with the different artifacts and forms of knowledge used in the workplace including work process knowledge. Furthermore, we are aiming to develop wider knowledge networks through communication, recommender systems and structured metadata and to develop an ecology for producing, editing and refocusing user-contributed learning materials.

7. Scaling the use of technologies though user engagement

There are many examples of effective and efficient innovative approaches to Technology Enhanced Learning in general and to developing PLEs in particular. However, there is a problem, arguably more severe when considering innovative project development, in rolling out such projects with large numbers of users. A central aim of the Learning Layers project is a significant up scaling of development and use to considerable numbers of users, both individual workers and Small and Medium Enterprises. Of course scaling involves technical development, but it can also be seen as a social design process. Learning Layers is approaching the latter through the development of a Stakeholder Engagement Strategy. A stakeholder is a person or an organisation that is interested in the research, development and upscaling efforts in Learning Layers and a user is a person or an organisation that is actually using some of the products or processes developed by the project (Learning Layers offerings). Stakeholders can be users and users are stakeholders.

The project has developed a strategic approach to engagement through ideas such as Open Innovation and an Architecture of Participation and is developing a model for user engagement. The model is particularly focused on participation and engagement through industrial clusters and supporting cluster development and innovation. The project has identified different stakeholder groups,and is researching their particular interests and motivations, what they may be able to gain from the project, and also what they might contribute. This in turn is allowing us to develop different initiatives for stakeholders based on Learning Layers offerings. Whilst there are many such initiatives being considered, two may illustrate the approach.

Developers are a particularly important stakeholder group for Learning Layers. The development of an ecosystem of apps for a Personal Learning Environment requires resources far

in excess of what even a well-funded Research Framework project can produce. Therefore the project is seeking to engage external developers in the design and development process. To enable this, two initiatives have been launched. The first is the Learning Layers Design Library and Open Developer Library. This provides early access to design ideas and processes, including, of course, beta releases of software as Open Source, but also paper prototypes, wireframes and use cases, released under a Creative Commons License. The idea is that developers can work to develop their own apps based on the co-design process described above.

The second is the Learning Layers Project Based Learning. This involves engaging with students following informatics courses who are increasingly required to work as a team for a semester-long project working for a real company. A pilot of this approach with the Technical University of Karlsruhe (HsKa), with Learning Layers partner, Pontydysgu, acting as an owner in a SCRUM development process, has already resulted in the release of an application, REFLECT, for capturing and reflecting on learning using an Android based mobile app.

The aim of the co-design process and the Stakeholder and User Engagement strategy is to develop new collaborative processes for designing and developing mobile Apps and PLE artefacts. This process is seen as a co-learning activity in itself, developing a PLE approach to the development of PLEs.

8. Conclusions

Educational technology and PLEs have made only a limited impact in Small and Medium Enterprises because technology based learning has imitated traditional business training models and approaches to learning. To some extent, that 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 PLEs 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 are particular opportunities to develop support for learning around the shared repertoire of communal resources and artifacts in emergent Communities of Practice.

In considering strategies for up-scaling learning, it is valuable to consider the links between learning and process and product innovation, and the boundary crossing that takes place within innovation networks. Through these processes, PLEs 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. A mobile PLE needs to support the different dimensions of know-what, know-how, and know-why and to enable skilled workers and learners to make informed choices between different possible ways of carrying out work tasks.

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. Ultimately the aim is to develop PLEs which are embedded in the practice of both learning and working, which can bring together informal and formal learning and which can facilitate the transfer and of knowledge, learning and innovation between different contexts and domains.

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