Paper Prototyping in a Design Framework for Professional Mobile Learning

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Abstract

This paper proposes a conceptual framework for the design of mobile learning solutions that address the special requirements of professional development. This framework is based on a combination of a game metaphor and the various dimensions of the mobile learning context. It provides the basis for a paper prototyping approach that uses sticky notes to represent both aspects of the display and supporting media types and components. We describe the framework and the paper prototyping approach and apply the prototyping method to some indicative content from a real world example. We reflect on the relationship between the framework and the paper prototyping method and outline further collaborative research with a partner organisation.

Keywords

Computer-assisted training systems, IS skill requirements, Prototyping

INTRODUCTION

Most of the published academic literature on Mobile Learning (M-learning) focuses on user requirements from the perspective of university students or school pupils, with little specific research focused on the commercial context. However some commercial literature addresses the special learning requirements of professionals, for example Gayeski's (2002) case studies. In this paper we have attempted to draw together a number of lessons from a range of academic and commercial sources, seeking to identify strategies that could prove effective in designing a professional M-learning system. We describe a conceptual design framework and instantiate this framework using a paper prototyping workshop in the context of a case study.

THE PROFESSIONAL MOBILE LEARNER

There are special challenges in designing an M-learning system for professional users. Importantly, unlike students or schoolchildren, their role is not defined by an expectation to learn formally and spend their time in a classroom. To professionals, particularly sales

professionals, time is money and therefore time spent on learning must be seen by them to be valuable. In addition, learning is highly dynamic in the commercial context and content must be current, more so than in many academic contexts. Because of this pressure on productivity*, just in time learning* is a common phrase (Koschembahr 2005), to the extent that some current views of M-learning have an on-the-job training focus, where workers in industries such as retail and fast food get what might be called 'fast learning' (McGee 2003), focusing on low level training modules and product information. A characteristic of this approach is the blurring of boundaries between acquiring information and learning. This encourages the view that, before long, an employee will not even be able to differentiate learning from other every day job functions. However this may not be desirable since education (as opposed to training) might take a broader, longer term view of professional development within the organisation. Perhaps one of the most important requirements in addressing these issues is to design M-learning content to be delivered as a professional down time activity. One of the commonly stated characteristics of M-learning content is that it should be delivered in short 'nuggets' rather than large units of information, while ensuring that the contextual integrity is maintained when content is decomposed (Luchini et al. 2004). Therefore this content needs to be highly focused, componentised and interruptible, with learning modules between 30 seconds and 10 minutes long, but must offer something more than just current product information and other transient data.

Tools and scenarios

One of the most important starting points for developing an M-learning framework is to understand that simply presenting material on a mobile device does not on its own constitute a learning environment. An M-learning system should enable the learner to construct and explore knowledge, converse and collaborate with peers, and control their own learning (Sharples et al. 2002). Successful mobile applications such as banking or buying parking tickets are goal directed, and are not effective if they expect too much reading from a small screen or distract with unnecessarily rich media objects (Uther 2002). As one alternative, Kurbel and Hilker (2002) stress the value of audio transmission, which can be combined with visual cues such as keywords, comments and illustrations. Audio transmission also encompasses audio conferencing, discussion forums of voice messages and voice based answers to on line tests. Freestyle drawing tools, which are available on many of the larger mobile devices, can also be useful to the learner (Liu et al. 2003). Real time streaming of video is an increasingly realistic option, but research is need to identify its value in terms of improving learning experiences (Liu and Choudary 2004).

Generic decisions about content are important at design time, since there is a need to identify media types included in the design process. A number of researchers give guidance as to important aspects to consider in the nature of M-learning content. Luchini et al. (2004) stress the importance of the user participating in and learning about underlying concepts and processes, perhaps using simulation tools, rather than learning by rote.

For the professional, it is important to try to contextualise learning into real-life situations. Work based scenarios are very useful for this, but it is important that these scenarios are not linear but involve many potential branches based on user interactivity. Setaro (2001) uses the medical context to indicate the usefulness of different outcomes depending upon the decisions made by the learner. Lundin and Nulden (2003) describe multimedia scenarios used in a professional context based on the PIER approach, which has four main building blocks: problem based learning, interactive multimedia, experiential learning and role playing. They outline a number of design approaches for these scenarios, including always leading to the same final scene with a common final problem, regardless of the branches that may take the learner to that point. In their multi user scenarios, learners take on different roles in a collaborative scenario based on real-world problems from the learner's organisation. Learners decide when and where to participate but still need to coordinate with the other participants. The inclusion of synchronisation points creates motivation for members to keep moving at a common pace and not be responsible for slowing down the other members of the group. The authors also propose the use of 'cliff-hangers' in the scenarios, points in the process when the participants are deliberately given a sense of failure and a problem to solve.

Discrete or integrated M-learning

A strategic issue in planning an M-learning solution is whether or not it will be integrated with other modes of educational delivery. Rather than being seen as a discrete delivery channel, it may also be regarded as a bridge between formal and informal learning arenas (Mifsud 2002). Indeed M-learning may be used as a pre and/or post activity to other types of learning, such as being in a real world context (Colazzo et al. 2003). In this type of delivery, M-Learning can complement the classroom experience, perhaps by covering issues that arise less frequently or simply by reinforcing previous classroom learning in a different way. A number of systems use mobile devices as a local messaging topology in face to face settings rather than in mobile isolation (Roschelle 2003). Even in an environment where there is no classroom time, M-learning solutions can benefit from the facilitator/leaner model, where there is a human teacher interacting with students via the mobile learning system (Liu et al. 2003). These interactive sessions can give structure to an otherwise fluid learning schedule.

The M-learning community

Roschelle (2003) emphasises that our analysis needs to have a complex view of social practices and a simple view of technology, not vice versa. The role of the mobile device is just that of a tool; a mediating object, neither in control nor an object to be controlled. Technological sophistication is not necessarily a measure of usefulness, since even simple technologies like classroom response systems have proved effective, engendering rich social practice around basic systems. Participatory simulations can assist understanding of emergent behaviour and collaborative data gathering with mobile devices can encourage more cooperative work. Both of these are highly social activities.

To engage the learner and draw them into a virtual community, two way interaction is an important feature of an M-learning environment. On the one hand there will be communication from the system to the learner. This may involve profiled notifications sent that are important to the learner's context (Koschembahr 2005), this context being defined by characteristics such as business unit, management level and job role. Other types of communication may be messages from fellow mobile learners or role play participants, general multicasts or more personalised communications from a learning facilitator (Rogers et al. 2004). On the other hand, there will be communication from the learner, which may involve submitting test answers, contributing to discussion groups, sending messages, writing blogs or adding to Wikis or sharing other information as part of pooled resources. Therefore mobile learning systems must provide the ability to upload resources to a central repository in a number of different formats. These resources may include rich media elements such as photographs or videos that can contribute to the learner's portfolio (Deviney and Koschembahr 2004) as well as being used as generally shared content (Trifonova et al. 2004). Such interactions support the essential characteristics of a shared learning environment, and these virtual learning communities, supported by mobile systems, are good for the organisation and the learner (Leung and Chan 2003). The ability to share problems enables learners to compare their solutions with others. Sharples (2002) uses the example of radiologists comparing their diagnoses of a case with others to reach a consensus. In the professional sales context we can envisage a similar approach used with customer needs analysis, discussing a set of requirements with other users.

The learner's ownership of content is a motivating factor. They can create, review and edit the content while the social aspect that is central to learning in a mobile learning community can support the shared corporate culture. In addition, the organisation benefits from the growth of answer gardens developed from pooled resources (Ackerman and Malone 1990). There may also be value in sharing learner models, as well as learning material, to compare understanding and promote collaboration (Bull et al. 2004). Of course all of this shared information needs enough metadata to distinguish between core material and individual contributions and also to encapsulate permissions on individual data, particularly learner models (Sharples 2002, Sharples et al. 2002). Walkers individualised 'pockets' (Walker 2004) can be a useful structuring approach here.

METHODOLOGY

Our methodology was to develop an M-learning framework based on best practice from the literature and to explore the validity of this framework by applying a paper prototyping technique to designing some M-learning content in the context of a case study based in a commercial organisation. In the following sections we describe the framework, explain the design process and discuss their application to a specific case.

Developing a framework

We have developed a conceptual design framework for M-learning based on a combination of design issues, dimensions of learning context, structural factors and their instantiation and objectives. The purpose of the framework is to encapsulate best practice, drawn from the literature, for building professional M-learning systems. Underlying this framework is a game metaphor, intended to engage and challenge the learner. The framework is user, device and content focussed, rather than considering the complete infrastructure. Leung and Chan (2003) describe a simple learning framework which is technology focussed, consisting of four layers, the mobile network infrastructure, the mobile protocol, the mobile user infrastructure and the mobile learning applications. Our intentions were to develop a conceptual framework at the mobile learning application layer. We also wished to decouple our initial design exploration from the potential limitations of a given technology platform. Thus our framework was intended to support an initial paper prototype phase that focused on the various media types and interactions that are necessary for M-learning, as well as some pragmatic considerations such as the generic form factor of the target devices, but not to pre-judge the client server architecture or the client device software.

Framework metaphors

There are two useful metaphors that have been explored in the context of M-learning that may enable us to both leverage the positive qualities of mobile devices and engage the learner. These are the cinematic metaphor and the game metaphor. The cinematic metaphor, as described by Walker (2004), provides us with a number of interesting ideas about how to involve the learner. The cinematic narrative enables users to explore roles, both their own and others. The use of fiction and emotional cues has the ability to deliver learning through the user identifying with characters and consciously reflecting on their actions. If the fiction is based on the users' reality (e.g. a sales scenario), then this basis in fact helps the viewer to identify with and comprehend it. The narrative can also be personal, including the record of ones own trail though the narrative and contribute to 'pockets' of user created contents. We can see that such a metaphor integrates well with the scenario based approach discussed previously.

The game metaphor is an important one, since in many cases an M-learning module will be competing with games or other diversions that a mobile device can provide during a professional's 'down time' (Colazzo et al. 2003). Thus new forms of teaching are required to encourage more time spent on activities. Schwabe and Göth (2005) describe the use of a game approach to M-learning, asserting that fun and excitement are motivational. They also provide a framework for their game based system developed from Prensky's (2001) six structural elements of games, namely rules, goals and objectives, outcome and feedback, conflict, competition, challenge and opposition, interaction and representation or story. Our framework is a development of Schwabe and Göth's, translated from the game environment into the professional M-learning context. It also integrates Wang's (2004) six dimensions of learning context: identity, spatio-temporal, facility (device, including adaptivity), activity, learner and community. We identity five design issues that are critical in professional M-learning: user roles and profiles, working on the move, different media types, interface design and collaboration support. We map these to Wang's six contexts and then to Prensky's structural elements. From these we address the learning objectives of the system: improved professional skills, loyalty and retention, organisational knowledge and team building. The framework is shown in Figure 1. The links that are identified are those that we see as most important, though most of the components will relate in some way or other. Key features of the framework are that it identifies the importance of the user's roles and the

learning community in meeting client objectives. We also identify those issues, dimensions and factors that have a user focus, contrasted with those that have a platform focus.

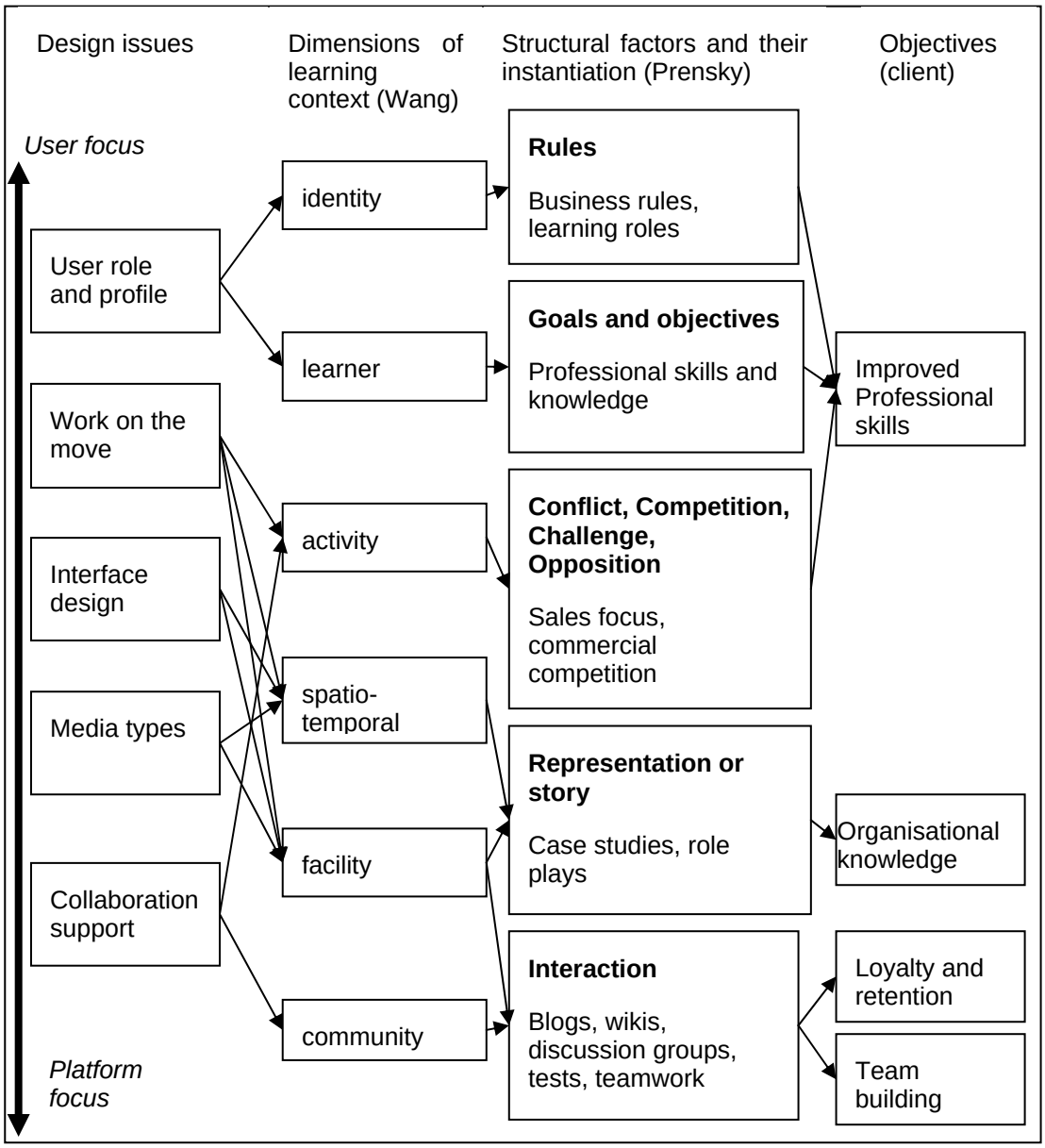

Figure 1: The M-Learning design framework

Paper prototyping with sticky notes

Having developed the initial framework, we specified a prototyping phase, with the intention of mapping the platform focussed components of the framework to our evolving prototype and taking the first steps toward validating the framework by testing it against a real world context. Many studies (e.g., Dix et al. 2004, Preece et al. 2002, Preece et al. 1994) have suggested that prototypes are a useful aid when discussing ideas with stakeholders, an important consideration in developing M-learning for commercial clients. These prototypes are generally used as a communication device among team members, and are an effective way for them to test out ideas, encouraging reflection in design.

We chose to use a lightweight paper prototyping approach using sticky notes, as described in Nehrling (2005). This approach is based on the use of paper prototyping materials for screen design that are specifically related to the physical size of the target platform. In this

approach the sticky notes serve two purposes. First, their size makes them ideal for the low fidelity prototype of the interface screens themselves, but equally importantly their portability and ability to be arranged (and re-arranged) on a vertical surface makes them an ideal tool to model the mobile user's workflow, and to maintain the conceptual integrity of the task decomposition (Luchini et al. 2004). Their key property is the ability to be moved into and between different environments and to link one piece of information to another in a precisely contextual way (Beato 2005). This property of being able to present information in context also makes them useful in designing information systems. They have been used in a number of different paper prototyping activities, including affinity diagramming (Snyder 2003), describing the page flow of a web site (Williams and Tollett 1997) and as overlays to other materials to show changes in content, such as showing pop ups or items in a spatial environment (Liu and Khooshabeh 2003). Another benefit from the sticky note prototype originates from the fact that an early evaluation is possible, since the users can interact with the sticky note prototype as though interacting with the real product. In fact, a human operator can simulate the responses to the users, so actual users can provide their evaluation of the proposed device. The use of sticky notes as a prototyping tool is just one part of a well-established practice of using tactile elements in the design of information systems. As well as being a useful approach to user interface prototyping, the tactile approach has long been successful in the business layer aspect of software design, perhaps most popularly in the CRC (Class, Responsibility and Collaboration) cards developed by Beck and Cunningham (1989). Low-fidelity paper prototypes such as this have been shown by many studies (e.g., Grady 2000, Nielsen 2003, Rudd et al. 1996, Sefelin et al. 2003, Virizi et al. 1996), to be as effective as high-fidelity prototypes.

In designing an M-learning system it is necessary to consider the various form factors of mobile devices (relating to the user interface and facility components of our framework). Weiss (2002) identifies three generic categories of screen size that we could consider. These three generic sizes are small (mobile phone), Medium (smart phone or pager) and large (PDA). Nehrling (2005) asserts that the specific advantage of sticky notes in the prototyping of mobile device interfaces is that some of their standard sizes map directly onto the screens of typical mobile devices. However in addition to screen size, we also need to be aware of screen resolution which can vary tremendously, and the further effects of user customisation of the device display, commonly available on PDA devices. Given these variations, our design approach was to use notes in two generic sizes; a PDA format of 3 inches by 2.5 inches and a mobile phone format of 1.5 inches square.

As well as using sticky notes as screen proxies, we also used different coloured notes when integrating different media objects into the user workflow so that we could represent the various types of content and interactivity included in our framework. The sticky notes representing the screen display map to the interface design issue, and the facility and spatio-temporal contexts. The other types of note represent the media types and map to the same contexts, thus supporting the representation and interaction of structural factors. This makes it possible to represent a total set of page components that act together but go beyond the visible boundaries of the screen. This approach has something in common with the concept of modelling object oriented designs in colour (Coad et al. 1999). In our colour coding, yellow is used for the screen ('interface design' and 'faclity'), orange for audio and pink for visual components (both supporting the 'representation or story' factor of the framework), while green is used for communication links or programs (supporting the framework's 'interaction' factor).

Prototyping mobile device screens with sticky notes is an extension of paper and pencil prototyping methods, so the same core activities apply to design workshops using this technique, namely: (1) identifying needs and establishing requirements, (2) developing alternative designs that meet those requirements, (3) building a conceptual design, (4) path determination, (5) accommodating for user error, and (6) prototype evaluation (Preece et al. 2002, Rauch et al. 1997). In our design workshops we focused on the first four of these activities, postponing accommodation of user error and prototype evaluation until the usability testing phase of the paper prototype.

Case study

The context of this research paper was a proposal to develop M-learning materials for an external client for whom a classroom based training programme was already being delivered on a commercial basis. As a multi-national company in the communications industry, the client organisation's employees typically have access to sophisticated mobile devices, thus part of the infrastructure for an M-learning solution is already at hand.

In the commercial M-learning context in which our study is based, there are a number of objectives for the client organisation. The most important objective is to improve the employees' professional skills in selling technology related products and services. Other objectives are to enhance employee loyalty and retention, to develop employees' knowledge of their own and customer organisations and to develop sales teams. The employee profiles within the sales area are differentiated primarily by the targets of their selling; large corporate and government customers, small to medium enterprises (SMEs) or retail customers. Each of these roles requires some different knowledge and skills but a common core of general technical and industry specific learning.

For this study, we chose to mobilise a short subsection of one of the current classroom based modules that presents a list of security vulnerabilities in mobile systems identified by Lee et al. (2004). The module discusses the mapping of security vulnerabilities to various components in an n-tier system. In the classroom this content would take up to 30 minutes for a user to complete including its associated exercise. The module's presentation content load is relatively low, with only two PowerPoint slides of notes, and an A3 handout of one of the slides is used in the classroom. The combination of material and exercise made this a suitably challenging component to translate into an M-learning context that met the criteria of our framework. During the workshop, sticky note screens and sticky note media objects were written, either on the desktop or sometimes attached to the device screens, to capture the M-learning content. Once the initial screen components had been prepared, they were moved onto the whiteboard for storyboarding activities to take place based on the underlying workflow and higher level navigation requirements.

Results of the workshop

One of the most useful outcomes of this physical modelling was in understanding the points of the system where different user interface components (from the design issues of the framework) would be required for certain types of content (the representation or story structural factor) depending on the facility available (within the learning context). For example, in one section of the learning material, the user is required to identify, on a diagram, the locations in a layered architecture where certain security vulnerabilities can occur. In translating this content to the M-learning environment it became clear that the larger screen could host an interactive diagram, whereas the small screen size would require us to decompose that larger diagram into more visually manageable components. Also, the lack of a stylus on most mobile phones meant that we had to design for a different form of user interaction.

Apart from gaining an understanding of the physical design constraints from the sticky note prototype, the process also provided a series of sketched screens for the workflow of the system, or a series of scene sketches showing how a user can perform a task using the device. In conjunction with a narrative description, the sticky note prototype can describe human activities or tasks in a predefined description that allows exploration and discussion of contexts, needs and requirements. It may explicitly describe the use of the proposed device or other technical support to achieve a task. This is, in turn, can be used for use-case analysis. This content focused aspect of the process feeds into the higher levels of the framework that relate to the identity, learner and activity contexts.

In addition, being able to represent the screens in the workflow with associated media objects proved a useful design tool because we began to identify a detailed design pattern evolving that could be reused throughout the M-learning system. The requirements of navigation through many pages meant we quickly adopted a layered navigation approach. Since small form factor displays cannot support the traditional frameset approach to render

the persistent, contextually persistent and dynamic elements of a page-style display (Golding 2004), we integrated into the design a standard set of tiny navigation icons (breadcrumbs) into a small screen header. We also identified a standard path through each 'nugget' that led the learner to an interactive 'answer garden' (Ackerman and Malone 1990) at the end of each learning objective, bringing the interaction factor of the framework into play.

Upon placing the sticky notes on the board, it became clear that attention was needed when defining the breadth and depth of workflows. Jones et al. (1999) found that users of small screens did not navigate as deeply as normal sized screens, thus making depth the more important factor of the two. The sticky notes allowed us to easily manipulate the workflows until a good balance was achieved between breadth and depth, which would in turn aid the user when navigating the system. Finally, using multiple colours for supporting media objects also proved useful in monitoring the richness of the M-learning solution. It was evident that any screen note that did not have some kind of supporting media object note was not likely to be very interesting for the learner and would not meet the criteria of the framework. A rule of thumb developed that each display sticky note should be associated with at least one other media object sticky note. Using a range of colours for the different media types enabled a high level view of the distribution of supporting media components across various learning paths.

CONCLUSIONS AND FURTHER WORK

The initial paper prototyping exercise appeared to support the framework's assumptions, in that a satisfactory prototype was one that mapped easily to the framework. At the end of the workshop we were able to establish the structure, various levels for each task, the flow and depth within each task and the type(s) of multimedia that would be used to the objectives of the framework. However the most difficult aspect of the design was to consider elements of conflict, competition, challenge or opposition. This structural factor implied that we would need to carefully consider the technology requirements of the server as well as the client, since the proposed scenarios (e.g. evaluating password strength) required a reasonably sophisticated programming model to enable the user to compete against either an application or other learners.

So far we have applied the framework in the context of using sticky notes for paper prototyping with a design team as participants. The next logical step for experimentation would be a usability study, to try to validate the approach with potential users from the client organisation. Once we have further refined the framework and prototyping process we expect to apply it in a vertical prototyping iteration of the M-learning system, following through a small M-learning component from design to implementation and testing. This will give us an opportunity to evaluate whether or not our framework approach is effective in anticipating the design and usability issues that may result from a real world implementation of a professional M-learning system.

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