Mobile HCI and the learning context: an exploration

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ABSTRACT
Recent advances in context-awareness provide the facility to track people and objects in the real world and to use these as a trigger for digital events to occur. We are interested in how context-aware mobile technologies can be designed to facilitate learning, and in so doing, to support the cycle between situated action in the real world and subsequent objective reflection. However, what it is to contextualize learning remains unclear. Therefore, we delineate emerging *constructs of context* and explore the issues surrounding the complexity of each for the learning process. We then draw out some implications for research into the design of contextualized learning applications for mobile devices.

Categories and Subject Descriptors
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Design, Experimentation, Human Factors, Theory.

Keywords
Context, learning, mobile learning, ubiquitous computing.

1. INTRODUCTION
The design and development of mobiles devices and services to support learning has become an area of significant research in the past years. A number of interesting prototypes have been tested, aimed at sectors as diverse as museum guides and mobile gaming (e.g CitiTag, Savannah). However, there has been little research undertaken on the nature of the relationship between mobile technologies, context and learning.

The idea of 'context' as a basis for the design of mobile applications is particularly appealing as it provides the potential for tailoring situations in a variety of ways relevant to the user at the time. The most obvious instance is based on information relating to the location of the user but can also, for example, enable tailoring according to task. With sensor technologies,, tailoring can be based on detection of the ambient environment. Thus, the potential of mobile devices and services to take context into account is a particularly powerful feature for supporting learning. However, for interactive experiences on mobile devices to do so in a meaningful way, a theoretically sound foundation regarding the *learning context* is required. This involves developing an understanding of the contextual requirements right from the initial design stages through to evaluation. This is a major undertaking that can only be successful if it is clear what is meant by learning context. To begin developing such an understanding, in this paper, we delineate the nature of the learning context through the identification of what we term constructs of context for learning.

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2. PERSPECTIVES ON CONTEXT
As can be seen from recent literature on the subject, context is a complex notion to define. Although the concept of context is developing and emerging with the advent of context-aware computing, there is no general consensus on what is meant by context or even context-awareness. Attempts have been made to define context, not only from different perspectives, but also within and across different domains.

Dey [3] provides an operational definition of context "as any information that can be used to characterise the situation of an entity". The focus of this definition is on the interaction between a user and an application. Significantly, Dey points out that context is about the "whole situation" but that particular aspects of the situation cannot be detailed, as they will change from situation to situation. Schmidt et al. [13] define context as "knowledge about the user's and IT device's state, including surroundings, situation, and to a less extent, location"

Within the ubiquitous computing community, the idea of context and context—awareness are strongly influenced by the pioneering work of Weiser [16]. This strand of research is technically motivated and espouses the view of the world *as* interface. Thus, context is determinable by sensors embedded in the physical environment in which a participant's activity is measurable. This implies that physical environments are information spaces and context—awareness is primarily an engineering problem to be solved. The solution then will be environments designed to support and adapt to the activities undertaken within them [2]. This outcome will free people from having to directly 'work with a computer' but instead allow them to engage in (computer supported) activity, where the focus is the activity and its environment rather than the computer itself.

However, the concept of context has always been about more than time and place. New technologies can be tailored to

different kinds of situations, driving us to be more explicit about what we mean by context. Dourish [4] proposes and alternative approach where primary emphasis is placed on the interaction between the users and technology, rather than on the technology itself. An important element of this approach is to investigate how this interaction occurs, focusing on the social, cultural and organisational elements. Indeed, this emphasis on the factors affecting an activity is precisely what makes it meaningful to the learner.

Dourish goes on to argue that the above approaches to dealing with context are not to be considered as opposing viewpoints: they are interrelated and supportive of each other. However, obtaining a mutually beneficial relationship between the social and the technical aspects is difficult. To address the issue, context is defined as an 'interactional problem', where people maintain a mutual understanding of the context of their actions and activities. As distinct from the technical approach to the problem, context cannot be considered on its own. It is not a stable, objective or measurable property of the world. Instead, it is intimately related to activity and is an emergent feature of it. One problematic issue with this concept of context is that it appears relatively unstable, subjective and could therefore be perceived as elusive. Such a concept poses problems for designing mobile devices and services for contextual relevance.

3. CONTEXT AND LEARNING

Any learning is critically dependent on context, or at the very least, is likely to be influenced by the context itself, and the learner's perception of it. Context-aware computing is advocated in learning because of its potential to relate information to time, location and the learner's needs and interests. The hope is that contextualized learning will be a more "compelling learning experience" [7]. However, if we are to deal with the complexities of this issue, we need to understand how context can de delineated and supporting applications developed to appropriately aid learning. We must therefore focus on the learner and investigate the theories of learning that support the activities they are engaged in.

The nature of learning is changing. The focus is no longer on the transmission of information from teacher to student but – broadly defined – on the social aspects of learning. In practice this means placing learning in a communal setting where students engage is social activities, often mediated by (mobile) technology.

3.1 Learning Theories

There are many theories of learning, ranging from behaviourist theories that emphasise a change in behaviour as an outcome of learning, to cognitive theories that emphasise changes in the way people conceptualise or understand the world. Socio-constructivist and socio-cultural theories place more emphasis on the historical, cultural and social context for learning. Vygotsky [18] claims that the socio-cultural situation is the primary catalyst for the occurrence of learning, and collaboration is central for supporting learners in reaching their potential. Such theories are highly influential in both educational practice and the design and development of technologies for learning, e.g., the concept of the zone-of-proximal development has driven the design and development of scaffolded tutoring systems.

Lave [6] also considers learning to be a situated activity, where the emphasis on social interaction and networks are primarily important in forming a 'community of practice'. In this context, learners collaborate, exchange information and share ideas to provide meaning and understanding across the community. In Suchman's [14] concept of situated learning, context provides meaning to the learning. For example, learning does not occur in the abstract domain of a classroom, but is contextualized in the domain of study (e.g., on a field trip). Brown [1] also rejected abstractions, advocating a type of apprenticeship where learning was not theoretically independent of the situations in which it is used. Clearly, mobile technologies can play a vital mediating role in supporting collaborative exchanges and sharing of ideas, as well tailoring learning activities to relevant learning domains.

Broadly speaking, by these definitions then, context is continually negotiated and redefined by people engaged in actions with artefacts and cannot be separated from this.

3.2 Contextual Models

Emerging advances in mobile technologies and context-aware computing provide new opportunities to capture and exploit the essence of context. But how can this be achieved? Can it be effectively understood to inform the design of mobile learning experiences? One way of achieving this is to develop contextual models of interaction. Lonsdale et al [7] defined a hierarchical description of context, using it as the basis for the development of a software architecture. Their model viewed context as a dynamic entity with historical dependencies, i.e., time-based. This allowed them to use information about the user as well as about the environment within which the user is engaging. The aim was to present relevant *content* based on the requirements of the learner. However, there are a number of interesting questions raised by this model regarding the premise that "by providing more appropriate information delivered most effectively, it allows the user to focus much less on the technology and more on the actual situation they are in". Conversely, research suggests that handheld devices can have a negative impact on interaction with the environment. For example, handhelds were found to reduce children's hands-on interaction with museum exhibits [7]. Critically, designing to ensure attention and activity are appropriately focused is of central importance in learning.

4. CONSTRUCTS OF CONTEXT FOR LEARNING

The concept of context in learning is diverse, and can be defined as being comprised of different components, interdependent in various ways. Context-aware computing is also complex, taking on different and emerging definitions as the field matures. To understand the value and relevance for learning of the concept of context, we need to investigate the different perspectives and ways in which mobile technologies can usefully support it. One way to do this is to begin to define the different *constructs of context* relevant for learning. However, it is clearly acknowledged that these constructs of context are closely connected and highly interdependent.

In delineating the constructs, we wish to investigate what is critical about context from a learning perspective. It is essential that we focus on the learner and their requirements by developing applications based on the specific constructs of context that we are interested in. Therefore, to support learning, context becomes more than the identification of dynamic environmental characteristics and is particularly associated with

the 'user context', including the social situation as described by Schilit [14]. Significantly, Mobile HCI has a defining role to play at the interface between the environmental characteristics and learner context.

The following constructs serve as a starting point for defining the learning context. Each construct impacts on the learning context in a different manner and can help in focusing the design and development process for mobile learning applications.

4.1 Context as historical/cultural/social

Learning takes place at different times in many different settings, e.g. home, school and work, continuing throughout our lives. The particular cultural/ social setting affects not only the learners' expectations of activity, goals, interaction, behaviour, but also the 'kind' of learning that might take place. The setting will usually define whether learning is perceived as 'formal', 'informal' or vicarious, and will shape the activity and task accordingly. In this domain, mobile technologies have been used, for example, in the classroom for mathematics education, for scientific field trips, and for museum exhibits.

4.2 Context as location

4.2.1 Physical location

One component of context-awareness is the concept of location-aware computing, where context, generally speaking, is defined according to location of the user. Context here refers to the location in the environment within which the user is acting/ interacting. This is a powerful mechanism for the delivery of information to learners in-situ, as illustrated by the proliferation of applications based on HP's Mobile Bristol software.

4.2.2 Social location

Also relevant to the location context is that of the current social situation. Awareness of people in close proximity (or not) may affect the contextually relevant collaborations that can take place. For example, in a collaborative or co-operative activity, effective sharing of knowledge and understanding may be influenced by the location of others, or the organization of the task itself.

4.3 Context as activity

Simply being aware of location is often not enough as the contexts of the *activity* undertaken, within the location, can differ enormously. The particular learning activity creates the context within which certain activities, interactions, tasks etc. will be defined. These will also be influenced by the intended goals and learning outcomes.

4.3.1 Learning task

The learning domain and the particular task provide the structure within which certain information, activities, and interactions are likely to be defined. The domain and task also provide a frame of reference for the learner, from which meaning is constructed and interpretations are made.

4.3.2 Social interaction/ collaboration

Collaboration has been clearly shown to be beneficial for learning (e.g., [17]), with different collaborative interactions being instrumental in different ways to the learning process [8,19]. The kind of collaboration that takes place also creates a different context within which to seat the learning. Research suggests that mobile and pervasive computing can support multiple collaborative interactions [9]. However, different collaborative interactions may need to be supported in different ways to be effective. Understanding this and the interaction between collaborative activity and other aspects of context (e.g. the learning task) will inform the design of context-aware devices and learning experiences.

An interesting avenue of investigation is how to exploit this context for peer-to-peer collaborative learning. Another open issue is how the 'activity context' maps to the location information and, more specifically, the precise nature of the mapping itself. This will have an impact on the level of context awareness required by the system.

4.4 Context of the user

The learner's current level of understanding and skill provide further context. Structuring learning activities that build on a learner's existing knowledge and take them beyond their current understanding is crucial for effective learning [1,19]. The history of the particular learner (or group of learners) in terms of their current level of understanding also provides a context for learning. The relevant context here is where that comes in relation to their past experience and what they already know. This will affect the kinds of learning activity, the learning task and learning content that will be appropriate.

Most clearly, the user context has implications for the design of the learning activity, task and contextualized context. However it may also have implications for using location information and supporting social interaction and collaboration.

4.5 Context as content

Contextualizing content is a rapidly developing area of research within eLearning, exploring optimum design and delivery of context relevant content for learners. However, one open issue here is identifying information relevant to which context – the learning domain, the task, the location or social interaction support? A further avenue of research is to explore how learners make contextual links; the effect of delivery mechanisms on contextual understanding; and its impact on learning.

5. IMPLICATIONS FOR MobileHCI

The implications for the design of contextualized learning applications for mobile devices are multifold and evolving. Here we offer some initial implications:

- *The relationship of constructs to context-awareness:* Constructs enable us to identify issues surrounding the design and use of mobile learning applications in relation to relevant contextual information. For example, GPS is commonly used to detect location. Such information can be used to deliver contextual information or to support a relevant activity or collaboration. However, the unreliability of GPS may have implications for learners' mapping and interpretation of content to environment or information about collaborators that significantly affects their activity, interaction, and interpretation of information.
- *Mobile learners are different to mobile users*: Learners are required to use an application to develop their understandings. Therefore, knowledge about their existing expertise may be required, fundamentally altering the focus of development and contextual relevance.

- *Design for construct interdependence*: The constructs of context are complex and intrinsically interdependent. Research has shown that delivering location specific information supports learners' interpretation and reflection, in relation to the environment and the learning activity [10, 11], demonstrating the need to design for construct interdependence.
- *Design for learning:* Before development, Mobile HCI designers need to consider the similarities and differences between differing learning situations and how contextual information can be used to delineate these. For example, by exploring ways of effectively supporting activity in relation to (i) where particular content is delivered or accessed relative to other content, (ii) the learning task (iii) the history of interaction or (iv) all of the above. Research is also exploring how mobile computing can support the bridging of the gap between different contexts for learning, such as outdoor and indoor learning (see e.g. [5, 11]).
- *Commonalities between contexts*: In designing for different contexts, what commonalities can be identified? What may be particularly of interest is not only which constructs can be effectively supported and how, but ways in which the interaction and interdependence between constructs can be facilitated, bridging the gap between various contexts e.g. formal and informal learning (Rogers and Price, in press).

6. CONCLUSION

The term context is used in different domains, at different levels of granularity. When we try to examine what we really mean by context, a complex picture of interdependencies emerges. Advances in mobile devices and services have enabled us to begin to think of ways in which context can be taken into account in many communities of life, but may be particularly powerful in learning settings. We are interested in how to design systems that can use such important and potentially useful information to effectively support learning.

The constructs laid out above make a start towards classifying the learning context, that may be used as a framework for investigating how mobile contex-aware technologies and applications can effectively support contextualized learning and the relationship between the different aspects of context.

Our immediate future work will be to develop contextual mobile learning applications based on the constructs outlined above. This will inform how useful our initial constructs are in designing mobile learning applications. We will also investigate where does it make sense to use them and where not to do so.

7. REFERENCES

[1] Brown, J. S., Collins, A. and Duguid, P. (1989). Situated Cognition and the Culture of Learning. *Educational Researcher*, 18(1), 32 -42.

[2] Bruner, J. (1973) *Going Beyond the Information Given*. New York: Norton.

[3] Coutaz, J., Crowley, J.L., Dobson, S. and Garlan, D. (2005) Context is key. Communications of the ACM, 48(3), 49-53.

[4] Dey, A. (2001) Understanding and using context. Personal and Ubiquitous Computing, 5(1), 4-7.

[5] Dourish, P. (2004) What we talk about when we talk about context. *Personal and Ubiquitous Computing*, 8(1), 19-30.

[6] Hine, M., Rentoul, R., and Specht, M. (2004) Collaboration and roles in remote field trips. In *Learning with mobile devices: Research and Development*. Learning and Skills Development Agency, London, UK.

[7] Hsi, S. (2002). The Electronic Guidebook: A Study of User Experiences Using Mobile Web Content in a Museum Setting. In *Proceedings IEEE international Workshop on Wireless and Mobile Technologies in Education*. 48-54.

[8] Lave, J., and Wenger, E. (1990). Situated Learning: Legitimate Peripheral Participation. Cambridge, UK: CUP.

[9] Lonsdale, P. and Beale, H. (2004) Towards a dynamic process model of context. In *Proceedings of Ubicomp Workshop on Advanced Context Modeling, Reasoning and Management*.

[10] Piaget, J. (1972). *The psychology of the child*. New York: Basic Books.

[11] Price, S., Rogers, Y., Stanton, D., and Smith, H. (2003) A New Conceptual Framework for CSCL: Supporting Diverse Forms of Reflection through Multiple Interactions. In *Designing for Change in Networked Learning Environments. Proceedings of the International Conference on Computer Supported Collaborative Learning*.

[12] Randell, C., Price, S., Rogers, Y., Harris. E., and Fitzpatrick, G. (2004) The Ambient Horn: Designing a novel audio-based learning experience. *Personal and Ubiquitous Computing*, 8(3), 144-161.

[13] Rogers, Y., Price, S., Randell, C., Stanton-Fraser, D., Weal, M., and Fitzpatrick, G. (2005) Ubi-learning Integrates Indoor and Outdoor Experiences, *Communications of the ACM*, 48(1), 55-59.

[14] Schilit, B., Adams, N. and Want, R. (1994) Context-Aware Computing Applications. In *Proceedings of the Workshop on Mobile Computing Systems and Applications*, 85-90. IEEE Computer Society.

[15] Schmidt, A., Asante Aidoo, A., Takaluoma, A., Tuomela, U., Van Laerhoven, K. and Van de Velde, W. (1999) Advanced interaction in context. In *Proceedings of First International Symposium on Handheld and Ubiquitous Computing*, 89-101, Springer Verlag.

[16] Suchman, L. (1987). Plans and situated actions: The problem of human-machine communications**.** Cambridge, UK: CUP.

[17] Tudge, J. and Rogoff, B. (1989) Peer Influences on Cognitive Development: Piagetian and Vygotskian Perspectives. In *Interaction in Human Development*. Lawrence Erlbaum Associates.

[18] Weiser, M. (1991) The computer for the 21st Century, *Scientific American*, 265(3), 94-104.

[19] Wood, D. and O'Malley, C. (1996) Collaborative learning between peers: An overview. *Educational Psychology in Practice, 11*(4), 4-9.

[20] Vygostky, L. (1978) Mind in Society: The Development of Higher Psychological Processes. HUP