Learning Contexts as Ecologies of Resources: Issues for the Design of Educational Technology.

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Abstract The question that motivates the discussion at the heart of this paper is how can we use technology to help learners (and teachers, peers and parents) to adapt the resources they find within a particular location to best support their learning needs. We present a description of a learning context as a *Learner Centric Ecology of Resources* and associated *Organising Activities* that can be deployed

desktop PC to mobile, pervasive and ubiquitous applications. Our motivation is to inform the development of educational experiences supported by technology to enable learners (and teachers, peers and parents) to adapt the resources at their disposal to best support their learning needs.

Previous research has indicated that the impact of technology is heavily dependent upon the specifics of an educational culture (Wood, Underwood and Avis, 1999). Wireless, mobile, and ubiquitous technologies bring with them the opportunity to link a learner's experience across multiple locations. We should be able to enable learners to access resources wherever and whenever they need them, to collect and record information in situ and to make selections about where they wish to work with greater flexibility than is offered by tethered desktop technology alone. These pervasive forms of technology also enable researchers to collect data about a learner's educational experience including the use of technology across multiple contexts with previously unattainable reliability. In other words we are poised to take advantage of the potential offered by these technologies for the creation of learning experiences that will engage learners in activities in real world learning situations, across multiple contexts and that can support collaboration and communication across time and space. We should be able to allow learners of all ages and motivations to access resources, such as information, software and experts or more knowledgeable peers, to enrich their educational experience and increase their understanding. However, the nature of what constitutes a learning context and the question of how best to apply mobile technologies in learning contexts is still open for discussion and exploration. Appropriate theories and frameworks are in their early stages of evolution and guidelines are only just starting to emerge.

In this paper we explore the nature of a learning context, the resource elements that comprise such a context, the way in which technology can be used to bridge different locations and how it might adapt, or help learners to adapt a learning context to meet their needs. There has been significant previous debate concerning the extent to which technology can and should control what and how a learner interacts with a particular subject or with other people. The emphasis within this paper is placed more upon exploring the extent to which technology might support learners, teachers, peers and parents in their organization of the resource elements that make up a learning context. Some locations such as classrooms are designed and then further adapted to greater or lesser extents to meet the needs of learners, other locations, such as a tropical rain forest may offer the potential for rich learning experiences, but have not been adapted to suit learners at all. These are of course two extremes, and there will be many shades of adaptation in between. The

introduces three additional constructs in an attempt to clarify and extend the ZPD. These constructs can help us to extract from the theory some of the implications for the specification of an educational context that might result in the creation of a ZPD between those individuals interacting within it. The constructs introduced by Wertsch are:

- situation definition,
- intersubjectivity and
- semiotic mediation.

A situation definition describes the manner in which a context is actively constructed and represented by those who are operating within it. The situation definition should incorporate an action plan and will differ between the interacting individuals. The communal action plan may not coincide exactly with that constructed by any individual. Intersubjectivity exists when two participants share the same situation definition and know that they share it. If the learner and the more able partner/s have different individual or personal situation definitions, collaboration within the ZPD may require a third interpsychological communal situation definition. This shared definition may correspond to the learner's personal situation definition or it may differ from both the learner and her more able partner's situation definitions. Intersubjectivity and situation redefinition will require a means of communication and negotiation, which is where semiotic mediation through, for example, language comes into play. We can now extract some functions that we need to support within our specification of an educational context. We need to define ways in which we can:

- Help individuals who are interacting within a particular context to externalize and share their situation definitions
- Help individuals in their construction of a communal action plan
- Provide the means for the communication and negotiation between individuals.
- Identify ways in which we can scaffold learners to a shared situation definition and therefore to intersubjectivity

We too have previously introduced two additional constructs in order to try and clarify the way in which the ZPD can be operationalised (Luckin, 1998) and have applied these to the design of educational software. The two additional constructs are: The Zone of Available Assistance (ZAA) and the Zone of Proximal Adjustment (ZPA). The ZAA describes the variety of qualities and quantities of assistance that need to be available to enable the more able participants to offer appropriate

assistance to the less able learner. When we develop educational experiences and environments our aim must surely be to maximize the variety of qualities and quantities of assistance that can be made available. A context or teacher who knows how to access a large ZAA has the potential, in principle, to deal with a wide variety of learners. However, the assistance that is selected and actually offered or otherwise made available to the learner needs to be matched to that particular learner's ZPD. This is where the Zone of Proximal Adjustment (Murphey, 1996) comes into play. The ZPA represents a selection from the ZAA appropriate for a given individual within a particular context. Clearly, if the ZAA is impoverished then this will limit the possibilities for the ZPA. Although, there will be situations in which

synonymous with the term as it is applied to network connection speed, we use it to describe the bandwidth of learner experience that we want to capture within the learner model. The concept and the design framework that we have developed from

Table 2 Organising Activities for the Resources that form a Learning Context

Activities

(Smagorinsky and Fly, 1993). This attention to the learning strategies developed by the learner, and the process of learning itself, underlines the need for knowledge about the learner. The importance of the link to culture likewise underlines the need for knowledge about a learner's context. Lastly we need to consider the medium of symbolic representations of the world through which communication is effected. Educational media can be classified into discursive, adaptive, interactive and reflective categories. For example, for the educational medium to be 'Interactive' it must involve learner's receiving "meaningful intrinsic feedback" on their task related actions and must result in an observable change to the world that can be attributed to these actions (Laurillard, 1993).

The findings that arise from this educational perspective confirm that the organisation of the learning resources will influence the manner in which these resources are used. They suggest that there is a great variance across individual locations even within the same environment, each will have its own unique culture, such as a class in a school. We need to ensure that we are able to represent and access knowledge about an individual's learning strategies and process, likewise her understanding of her context and the knowledge or skill being learnt. The creation of effective instructional interactions is complex and each learner will need effective feedback that identifies the way in which the context situation definition has changed as a result of her actions.

The work we consider from computer science has arisen from the ubiquitous computing community. Most of this work has been about defining context in a manner that will enable the development of 'context aware' applications. It is therefore motivated by a technical device design aim and is not specific to educational contexts. Context has been defined by Dey (2001) for example as "any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves". For application to an educational context an entity could be considered to be the learner and therefore context would be the information that characterizes the learner's situation. This approach might help us to identify the information to which we would wish technology to respond in order to assist the adaptation of the resources in the context to the needs of the learner.

Some more recent work has critiqued this notion of context. Dourish (2004) identifies the challenges that ubiquitous computing technology has brought to human-computer interaction design and the confusion that surrounds what it means for a device to be context-aware. He proposes greater attention be paid to the

nature of human activity. In a similar vein, Chalmers (2004) examines a number of the approaches, origins and ideals of context-aware systems design. He concentrates in particular on the way that history influences ongoing activity and suggests that an individual's experience and history is part of her current context. If we apply this purely to an educational context, there is great consistency with a sociocultural approach in which all the resources within a context will be culturally defined and therefore bring with them a historical definition that will influence a learner's ongoing interactions.

Work which tries to combine the educational and technological perspectives on the nature of context can be found in the mobile learning and AIED literature. The MOBILEARN team have started to look at how context modeling can be applied in a variety of learning contexts in order to build systems that can respond appropriately to contextual features. Beale and Lonsdale (2004) for example, present a hierarchical description of context which they define as "*a dynamic process with historical dependencies*." This is described as "a set of changing relationships that may be shaped by the history of those relationships". Research within the AIED community has explored how we can design adaptive technology that takes a learners' context and potential collaborators into account (Greer, McCalla, Cooke, Collins, Kumar, Bishop, and Vassileva, 1998, and Murray and Arroyo, 2002 for example). Much of this work is also grounded in a socio-cultural approach to understanding the learning process and has explored the ways in which technology can adapt to scaffold learners' collaborative interactions. As yet however it has concentrated upon desk-top technologies.

Socioculturally Informed Technology Design

It is useful to also consider how both sociocultural theory and the notion of context have been used to date by designers of educational technology. The idea of using sociocultural theory to inform the design of educational technology is not new. The desktop metaphor and the design of Interactive Learning Environments (ILEs) using the scaffolding techniques proposed by Wood and colleagues for face-to-face interactions have been used to implement software scaffolding and have offered designers one way of implementing flexible assistance for learners of different ages. A range of different approaches to scaffolding have been implemented, including systems designed for single learners (Wood, Shadbolt, Reichgelt, Wood, & Paskiewitz, 1992) and to support collaboration amongst groups of learners (Guzdial, Kolodner, Hmelo, Narayanan, Carlson, Rappin, Hubscher, Turns, & Newstetter, 1996). Likewise, there is a large literature on the benefits of peer collaboration in

general (e.g. Dillenbourg *et al.,* 1995), in paired reading (Topping, 1988) and in learning through interactive multimedia (Jackson *et al.,* 1996). The question of effective collaborative assistance has been extended beyond the *content* of the help provided by a collaborator (human or digital), to *how* that help is made available to learners and how well learners can seek the assistance they need. Various recent studies have shown that learners do not always make effective use of the available help (Luckin & du Boulay, 1999; Wood & Wood, 1999; Aleven & Koedinger, 2000; Luckin & Hammerton, 2002; for example).

However whether concerned with designing help, promoting peer collaboration or exploring how learners ask for help, the emphasis of the software scaffolding work completed to date has been directed at the desktop computer metaphor. Some of our previous work has explored what happens when the helper is taken out of the box. In particular, we have conducted empirical studies with digital toy technology that allowed young children to request help directly from the digital toy, from the accompanying software, from their peers, or from a researcher. We found that even with the basic technology used in these studies there was an increase in the level of social interaction that occurred between collaborators when the toy was present as compared to that which we observed when children interacted only with the desk-top screen based interfaces

Moving further beyond the desktop and outside the classroom context, wireless, mobile and ubiquitous technologies can engage learners in hands-on experience and activities in real world learning situations. As we have previously identified in Smith, Luckin, Fitzpatrick, Avramides and Underwood (2005) such activities can lead children to be more imaginative in their understanding, can yield both motivational and cognitive benefits and offer learners greater ownership of their data.

Discussion and Conclusion

We have presented an educational context as an “Ecology of Resources” that can be deployed in a learner centric manner through the implementation of organizing activities. As we stated at the start of this paper our motivation is the development of educational experiences supported by technology to enable learners (and teachers, peers and parents) to adapt the resources at their disposal to best support their learning needs. Different locations will be more or less adaptable, however the smart use of technology can maximize the amount of assistance that the learner can glean from her environment and ensure that it is targeted at her ZPD.

The *Ecology of Resources* framework as we have presented it is still relatively abstract. It consists of a description of the categories of resource elements that constitute a context and the organizing activities that activate these resources to form an Ecology of Resources centred around the learner. This approach has the advantage of encompassing a wide range of context types, and has proved useful in

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