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Context and deep learning design

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ABSTRACT

Conceptual clarification is essential if we are to establish a stable and deep discipline of technology enhanced learning. The technology is alluring; this can distract from deep design in a surface rush to exploit the affordances of the new technology. We need a basis for design, and a conceptual unit of organization, that are applicable across constant technological change. These are the issues addressed in this article. The article first explores the nature of 'deep learning design' where the aim is to shape the possibilities of the technology to most effectively enhance learning. These design insights need to be applied to a unit of organization that is not dependent on any particular technology. They should interact with and shape technology possibilities rather than be narrowly defined by them. The key unit of organization proposed is that of context. At a theoretical level, the article explores context as a shared interpretation of situation. The implications of the nested nature of contextual interpretation on design, implementation and evaluation are explored in depth. The internal dynamics of learning contexts are then discussed initially in terms of principles, heuristics and scripts. The contribution of this article is to present a coherent argument for context as the central unit for deep learning design, and to articulate the incisive theoretical and practical consequences of this position.

1. Introduction

Give me a place to stand and with a lever I will move the whole world.
Archimedes

The quote attributed to Archimedes captures in a striking way the amplifying power of technology applied from a "place to stand". In the 21st Century we have abundant levers of technology to use in "technology enhanced learning". The key question addressed in this article is – where is the conceptual "place to stand"? The challenge is increased by the rapid and continuous changes in technology. Can we establish a stable conceptual place that enables us to use the levers of technology in a principled and effective way? As new waves of technology sweep in, can this place remain stable as a conceptual vantage point? This challenge is addressed in this article through an exploration of deep learning design.

Deep learning design is about generic principles that can be applied to support learning in technologically mediated situations that are not dependent on or narrowly derived from the technology. It was originally proposed by Ravenscroft and Boyle (2010) in the context of dialogue and social media and then expanded upon to cover a range of learning situations (Ravenscroft, Boyle, Cook, & Schmidt, 2010). In this article we develop the approach to argue that deep learning design requires a central organizing unit to encapsulate the way that it imaginatively exploits the technologies at play. The technology constantly changes; it is not a stable base for specifying general principles. The key organizing unit proposed for deep learning design is that of 'context'. This concept occurs repeatedly in the literature of technology enhanced learning; yet its definition and articulation remain elusive.

There are a number of areas of research and development where context has emerged as a central, if problematic concept. These areas include:

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- Computer Supported Collaborative Work and Computer Supported Collaborative Learning (CSCL) (e.g. Hernandez-Leo et al., 2011; Morris & Joiner, 2002);
- Ubiquitous Computing (UbiComp), with its focus on "context-aware" software (e.g. Chalmers, 2004; Dey, 2001; Dourish, 2004);
- Burgeoning interest in Mobile Learning (Dede, 2011; Pachler, Bachmair, & Cook, 2010);
- "Learning Design", and pedagogical patterns, with the emphasis on patterns, often captured as 'scripts' for reproducing learning contexts (Mor, 2011);
- Technology enhanced learning more broadly where "context" is designated as a basic unit for design (Boyle, 1997, 2002; Luckin, 2010).

A central theme of this article is to explore and articulate a clear conceptual understanding of what is meant by "context". This provides an essential foundation for articulating generic principles of deep learning design. The focus in this article is on design for technology enhanced learning. The discourse in related fields is addressed as it impacts on the discussion and clarification of key issues. We thus aim to open up our understanding of context in ways that allow us to define and design more contextualized and meaningful TEL experiences.

The thematic development of the article is as follows. Section 2 clarifies what we mean by deep learning design. In Section 3, context is posited as the central organizing unit around which principles for deep learning design may be articulated. This section discusses approaches to understanding context and the distinction between type and instantiation. Section 4 discusses in more depth the layering of learning contexts and the implications that this has for design. Section 5 then moves to discussing the crucial challenge of how to explicitly capture, represent and communicate context-rich design ideas. The section reviews principles and heuristics for designing engaging contexts for learning. This is followed by a review of more formal attempts to capture reusable designs in the form of scripts or languages that generate contextual narratives. The final section returns to the overall issue to encapsulate the arguments for context as the principal unit of organization. It re-iterates the central theme: the focus on learning context as a central organizing unit, rather than just a vague backdrop to action, encourages and supports rich designs for learning.

2. Defining deep learning design

This section develops previous work of the co-authors (Ravenscroft & Boyle, 2010) that introduced deep learning design. This earlier research emerged from dialogue-rich and social software perspectives on TEL, and outlined an initial framework for deep learning design and the principles that defined it. This work had a particular emphasis on 'designing in the Web 2.0 landscape and beyond'. The generality of this initial framework was tested and reported in Ravenscroft et al. (2010) that extended it to a range of TEL initiatives, including mobile learning and reusable learning objects. In developing this line of work this article takes a much deeper focus on the relationship between context and design. Deep learning design requires a unit of organization that is independent of particular technologies. The article explores how significant theoretical articulations of context are important to both better understand context, and to clarify the relationship to deep learning design.

Two of the fundamental influences that feed into technology enhanced learning (TEL) are the affordances of the technology, and design that exploits those affordances. The exploitation of this synthesis has the potential to create powerful contexts for learning. Design may be shallow or deep. One trend in what might be termed shallow learning design is to put 'old wine in new bottles'. Familiar ways of structuring are superimposed on the new technology, rather than a fresh examination of a learning situation followed by a creative configuration to exploit the new opportunities. Thus in Second Life, we often have lecture halls and PowerPoint presentations, because these are the familiar educational structures. The teaching-learning situation is not sufficiently critically examined or problematised. The affordances of 3D immersive technology are not fully exploited because designers have not thought deeply enough about the possibilities for creating new learning contexts. Here the notion of creative 'problematisation in order to change' is crucial in designing enhanced contexts for learning. The absence of this process is often the reason for shallow designs.

So what is deep learning design? The previous work that we have built upon (Ravenscroft & Boyle, 2010) defined deep learning design as a framework that required:

1. Articulation of a suitable conceptual framework based on a deep understanding of learning;
2. Design that seeks to creatively exploit the new interactive functionalities and affordances of the technologies;
3. Learning as interaction in context;
4. An evaluative approach linked to the conceptual foundations and the design process.

Our current thinking and definition can be expressed simply as:

Deep learning design encourages the creative study of a learning problem or opportunity. It applies substantive insights from the learning disciplines to exploit the affordances of the technology in order to develop contexts that empower learners to achieve educational goals.

The essence of deep learning design is thus to realize effective design principles and techniques through the possibilities offered by the technology. This overarching perspective is generic and not tied to any particular technology. It provides insights into how to exploit the affordances of the available technology to enhance learning. Principles and techniques that provide deep insights into how to develop effective learning contexts are key within this framework, such as principles for authentic learning (Herrington, Oliver, & Reeves, 2003; Herrington, Reeves, & Oliver, 2010) scaffolding (Bruner, 1975; Wood, Bruner, & Ross, 1976), and the treatment of errors (Papert, 1993). We do not present deep learning design in a narrow or exclusive sense. It is essentially an exhortation to create a deeper basis for TEL. Context is crucial because we cannot achieve significant progress without thinking deeply and clearly about the nature of contexts for learning.

3. Context as the central organizing unit

Herrington et al. (2010) identify "authentic context" as a central requirement for effective learning. Although the concept of "context" is central to their arguments, it remains ill defined. They use Rogoff's (1984) definition of context as the problem's "*physical and conceptual*

structure as well as the purpose of the activity and the social milieu in which it is embedded" (Herrington et al., 2010, p. 19). This definition begs a number of questions, e.g. what is the conceptual structure? The "as well as" does not inspire confidence. It seems to concatenate items that are clearly important but not integrated into the conceptual structure of the definition. This combination of positing context as central, combined with vagueness in articulating what it means, is common in the literature on technology enhanced learning. This section seeks to clarify our understanding of "context" as a key organizing construct for learning design.

3.1. The nature of context

Boyle (2002) has argued that the concept of context is of central importance for learning design. This position is perhaps more salient now, as recent advances in technology increase opportunities for more varied forms of learning context, as emphasized by Luckin (2010). Following Anderson (1990) Boyle delineated three possible layers of explanation for learning: the physiological, cognitive and interactional layers. He argues that the interactional layer is the appropriate one for the learning designer and that 'context' is the key concept at this layer. He thus proposes context as the "natural base concept for the learning technologist" and that "the central challenge for educational designers is to create contexts that promote effective learning (Boyle, 2002)". Practical guidance on how to achieve this goal is derived from several contributory disciplines, especially linguistics (Coulthard, 1985; Halliday, 1975), film theory (Hodges & Sasnett, 1993) and psychology (e.g. Bruner, 1990; Donaldson, 1978).

Cole (1996), in his ambitious and thought-provoking delineation of a discipline of "cultural psychology", also poses 'context' as a central explanatory concept. Cole anchors his approach to context in the sociocultural work of Vygotsky and his successors (e.g. Bakhtin, 1986). The sociocultural tradition emphasizes the crucial role of mediating tools in our understanding of the world. We understand the world both at the level of sensuous experience but also crucially through the abstracting filter created by semiotic systems such as language. Cole extends this emphasis on mediating tools to mediating artifacts more generally. Contexts are treated as second order mediating artifacts – as idealized representation of situations in which we find ourselves. We simultaneously experience the sensuous aspect of a situation as real people and real things, and *its mediated aspect as an instantiation of a cultural context*.

3.2. Approaches to understanding context

Cole (1996) outlines two principal perspectives on context:

- context as container – context as that which surrounds;
- context as that which weaves together.

Cole (1996) provides a perspective of contexts embedded within each other – visualized as a series of concentric circles. Fig. 1 illustrates the nested layering of contexts, with a particular example. In this example, the focal activity (the context of a small group discussion) is framed within the larger contexts of a seminar located in a module. Similarly, informal learning in the workplace may involve a collaboration to solve a particular task that is part of workflow for a particular department that is part of an organizational policy aimed at maintaining or improving profitability. This "nested contexts" approach to understanding how context operates is important. One important implication is that in designing and *evaluating* any learning context we will need to be critically aware of the relationship to the higher order containing contexts in which it is activated and used.

The fact that something is contained within something, however, does not specify the nature of that which is contained. Cole does not fully clarify this distinction. The question remains – how do we conceptualize this entity called context? Nardi (1996) compares three strategic approaches that contribute to this understanding: activity theory, situated action models and distributed cognition. Nardi finds value in all three approaches, but her primary emphasis is on the contribution of activity theory. Context is viewed as an activity system. Context is constituted through the activity of people interacting with resources to achieve a goal. These 'context patterns' are acquired as a result of historical and developmental processes. Boyle (2002) argues that context is a *gestalt interpretation that makes sense of the situation* and frames and shapes our actions in that situation. This constructive understanding operates at both the social and psychological levels, i.e. it is intersubjective. It is this shared understanding that enables joint action and co-ordination in the unfolding of context-mediated interaction.

The second conception of context discussed by Cole – "that which weaves together" – contributes to our understanding of context as a holistic entity that is greater than the sum of the parts. This perspective on context is rather neatly illustrated by a slogan seen on an advertising board: "You are not in the traffic. You are the traffic". This perspective is particularly relevant to dealing with the question of how do we get from the prototypical to the real – how are actual contexts developed and maintained? Cole points out that context creation is an actively achieved two-sided process. For a lesson to occur the participants must engage in the consensual process of lesson making. The degree and quality of this engagement, however, will be constrained by the conception of the context type. Thus a "lecture" will normally

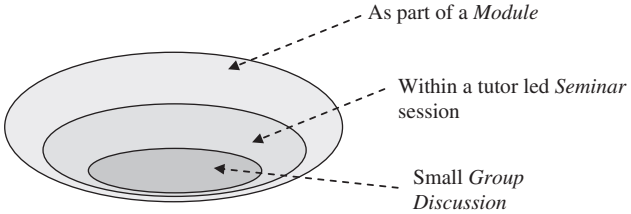

Fig. 1. Nested layering of contexts.

lead to more restricted interaction than a "seminar". The dynamic between the perceived context type and the dynamic weaving of the actual context by its participants is crucial in understanding contexts for learning.

3.3. Perspectives from ubiquitous computing

The challenges of ubiquitous computing and TEL overlap in the need to understand and conceptualize the impact of context on design. The arena for ubiquitous computing arises from the transition from the traditional desktop scenario to activities in the world supported by a range of embedded and mobile devices. This section succinctly examines the contributions from the ubiquitous computing "engineering" approach to context, and then reviews an influential, socially-oriented critique of this approach. The purpose is not to provide an extensive exposition of these positions, but to clarify the potential contributions to a deeper understanding of context in TEL.

3.3.1. The ubiquitous computing "engineering" perspective

The need for a deeper conceptualization of context is demonstrated by the somewhat limited definition and articulation of context associated with work into ubiquitous computing and context-aware systems (e.g. Beale & Lonsdale, 2004; Berri, Benlamri, & Atif, 2006; Dey, Abowd, & Salber, 2001; Hu & Moore, 2006; Schmidt, 2007, chap. 16). This work typically defines context in terms of environmental features that context-aware technologies can acquire and incorporate into interactions – such as location, the physical presence of potential peer learners and the tagging of particular physical aspects of the environment. In this ubiquitous computing work context is typically defined by what the technologies can do to support a task or interaction, and not what is important about understanding, creating and evolving contextualized learning experiences. This often lacks conceptual cohesion and leads to definitional confusion. Although the inclusion of useful environmental features that technologies can easily acquire and incorporate into learning interactions is useful in itself, we argue that this doesn't amount to understanding and modelling of context. This is demonstrated in the definition by Dey (2001) that Schmidt (2007, chap. 16) argues is the generally accepted definition of context amongst the ubiquitous computing community: "*Context is any information that can be used to characterise a 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 application themselves.*" However, Schmidt (2007, chap. 16) points out that, although "situation" is key, Dey doesn't go on to define what a situation is. What is presented here, as so often in ubiquitous computing definitions, is a list of features. In brief, ubiquitous computing in relation to TEL often currently asks: how can easily acquired environmental features be incorporated into learning contexts? It could be asking more broadly: what are the defining features and holistic conceptualizations of learning contexts? Making progress in answering this latter question is precisely what this paper is aiming to do.

3.3.2. The ethnomethodological critique

Dourish (2004) presents an influential critique of interpretations of context in ubiquitous computing. Although presented as a critique it stands in its own right as a radical conceptual approach to understanding context. It is not oriented to TEL, but this approach contributes to a fuller exploration of contextual concerns in learning design. The approach that Dourish adopts is explicitly based on an ethnomethodological perspective (Garfinkle, 1967). This emphasizes the rich, detailed "weaving" of context by social actors through local, contingent interactions. In fact, he argues (following the ethnomethodology tradition) that contextualization *only* exists at this level. Contexts do not exist as separate stable, conceptual entities and, therefore, cannot be designed in advance. The role of design is to create software that supports these dynamic, local activities that weave contextualized meaning from below.

It is beyond the scope of this paper to go into a detailed examination and critique of this complex paper. For a very good, systematic critique see Chalmers (2004). We have extracted two themes from the argument by Dourish (2004) that are particularly relevant to the synthesis being developed in this paper. One of these themes is positive in potentially extending the synthesis – the emphasis on rich, local interaction. The second is critical – the rejection of the notion context as situational "framings" that can be designed for in advance.

We will address the critical claim first. In order to address this issue we will use the conceptual approach advocated by Dourish: rather than ask is the argument true or false, we ask what conceptual work does the construct do – specifically, in our case, in design for TEL? Can we have a design discipline for TEL is which the design or planning of learning contexts is absent? One of the characteristics of "ubiquitous computing", as the name suggests, is that it is applying computing to situations that already exist in the world. In education, however, the teaching and learning situations are not just found "in the world". In formal education, especially, there is a whole framework for planning formalized teaching and learning situations: lectures, seminars etc. The "Learning Designer" tool, for example, incorporates a systematic list of such educational entities for design purposes (Laurillard et al., 2011). A major theme within TEL is the critique of traditional "disembedded" formal contexts and the argument that we need to replace these with the design of more authentic contexts for learning. An ethnomethodological approach does not give us the tools to deal with this problem, largely because this problem does not exist within its conceptual framework. An ethnomethodological approach on its own is simply insufficient to "do the conceptual work" in tacking certain major challenge for TEL.

The strength of the ethnomethodological approach advocated by Dourish is that it focuses attention on rich, contingent user interactions. Dourish points out that the context as perceived and acted in by the user may be radically different from that envisaged by the designer. The situation as designed, and the situation as perceived and acted in, may be significantly different. This may be particularly marked in online eLearning. At a conceptual level this points to the crucial relationship between design and local activation. At a practical level it points strongly to design that engages the users as active, and reactive constructors of the learning situation, We need designs, from this point of view, that free learners to be active, constructive and creative. This is in tune with and reinforces constructivist approaches to learning design. These contrast with more traditional (e.g. behaviourist) approaches where teachers try to ensure that learners go through rigid, predefined steps to ensure "correct" learning.

3.3.3. Clarification of the synthesis advanced in this paper

The ethnomethodological perspective focuses on adaptive, reactive interaction in a situation. This article has emphasized the pro-active interpretation of situation that guides adaptive action in the first place. This interpretation is:

- pro-active, not just reactive
- holistic (it makes sense of the situation as a whole);
- shared or intersubjective;
- has adaptive validity: it is viable in making sense of the situation It provides guidance for engaging in appropriate, adaptive action and thus in co-ordinating activity with other actors

It is essentially an ecological concept, at a deeper level even than being social. It is about the holistic interpretation of situation and the guidance that gives for adaptive action. This framing may be strongly or weakly structured. The degree to which participants have freedom to weave contextual coherence from below is shaped by the strength or weakness of the perceived contextual structure. At one extreme we have ritual where the roles and "script" may be almost totally pre-specified, e.g. in certain religious ceremonies. In education, the lecture is perhaps the most strongly framed context where power, roles and privileges of contributions are strongly, and rather rigidly, demarcated. The "conversational" freedom to innovate, negotiate and mutually construct coherence is a consequence of the design framing of educational contexts. Indeed, a consistent theme in much constructivist writing has been the need to move towards more open contexts that encourage learner autonomy, decision making and constructive activities. The balancing emphasis from an ethnomethodological approach is the realization that the rich texture of contextual interaction cannot simply be pre-scripted. An interpretation is a starting point (and an ongoing reference point). How can design go beyond this to create the circumstances that promote particular activations of context that promote effective learning? We need an approach to context that deals with both aspects of context – shared generic understanding, and rich, local contingent learning. This issue is explored further in the next section.

3.4. Context type and instantiation

Contextual interpretation must be shared by people to enable us to make sense of and co-ordinate our activity. But these joint understandings are far from perfect. There is scope for considerable variation in interpretations across individuals and different social groups. There thus remains considerable need for negotiated interpretation when the contextual framings become activated. Contextual interpretation is not entirely pre-given. Historically based understanding gives us is a starting point for negotiated interaction. Real, living contexts have to be generated by the participants in the context.

This brings to the fore the important distinction between context *type* and context *instantiation*, or context as abstract frame and context as lived-in experience. This is illustrated sharply by the nature of games. A game, such as football, provides an abstract structure of goals, rules and typical practices, for generating context instantiations. Games can be played because the players share this common understanding. The actual game, however, must be co-constructed, even in adversarial games, by the players. In fact, the excitement of games arises from the unpredictability of the course of the instantiation (the underdogs might just win). Lived-in, instantiated contexts are *woven* – to use Cole's term – by their participants.

The idea of making learning contexts explicitly 'game-like' has been popular as a way of transforming educational contexts to create more engaging experiences for learners. One refined example is the work into Digital Dialogue Games and the InterLoc tool that realizes them (Ravenscroft et al., 2010). This is an innovative TEL approach that stimulates critical thinking and reasoning by scaffolding the generation of original learner-generated 'texts' arising from synchronous dialogue. In this approach, a tutor or learning manager sets up an initial design for a dialogue game through linking: an activity (e.g. a group discussion session); a curriculum requirement (e.g. DNA testing in Biology or Criminology), and web-based content that seeds the dialogue game (e.g. articles and videos about the science and ethical issues of DNA testing). This pre-structuring produces an initial framing for a context that is 'weaved' together during the live dialogue game as it is performed by the players (students) in real time. This weaving involves a small group of 4–6 players, through live dialogue, weaving a collective critical understanding within the constraints and affordances of the defined contextual frame. The way this dialogue-rich weaving process occurs, linked to connectivist theory (Siemens, 2006) is described in detail in Ravenscroft (2011).This approach illustrates how contextual frames set up by a tutor – rather than constrain students – can seed and facilitate rich learning interactions. This approach synthesizes characteristics that go naturally together in good design: the outline design of contexts by teachers, and the emergent creative activity of students.

The type of dialogue game can be refined further as 'critical discussion and reasoning', 'exploratory dialogue' or 'creative thinking', by a tutor, prior to its live implementation. The live performance of these games by students in real time realizes the instantiated context. The crucial aspect of the Dialogue Games design is that each type of discussion is scaffolded by appropriate 'prompts' the students can use during the discussion. The key aim of the design is to facilitate effective discussion even though the exact nature of any discussion cannot be, and should not be, predicted in advance.

This relationship between context *type* and *instantiation* thus has important implications for design. One important factor to consider is the relationship between the designer and the activated context. Is the designer an actor in the context, like a teacher who both designs and runs an interactive seminar? Alternatively, is the designer a pre-constructor of the learning context, but not a participant? With the growing impact of Web-based distance learning and Open Educational Resources (OERs), the designer will be increasingly remote in time and space from the learners. This has implications for design (Lane, 2010). How do we design for each of these situations?

The 'designer as actor' is the more familiar situation in traditional education and work-based training. This has implications for how design is represented and linked to action. Designs do not have to be complete or fully explicit. The teachers/trainers can elaborate and adapt flexible ideas in situ. In the second scenario, however, designs have to be represented and communicated in a more complete and explicit form. They have to be explicit, shareable and open to public scrutiny and criticism. Explicit representation and communication is an important challenge for deep learning designs. This is an important issue which is elaborated in Section 5 of the article.

4. Design implications of the layering of contexts

Before looking at the internal design of contexts for learning it is important to discuss the potential design implications of the layering of contexts. Boyle (2010a) elaborates a more complete, and abstract model of the layering of contexts in education. This reference model has two

dimensions: the vertical dimension sets out layers of educational contexts, where each layer provides a service to help achieve the goals of the layer above. The second (horizontal) dimension deals with the instantiation of designs. It links learning design to the extensive work on classifying learning objects – such as the ALOCOM reference model (Verbert, 2008; Verbert & Duval, 2004) – by treating learning objects as instantiations of learning designs. Fig. 2, reproduced from Boyle (2010a), provides a simplified view of the model mapped to higher education.

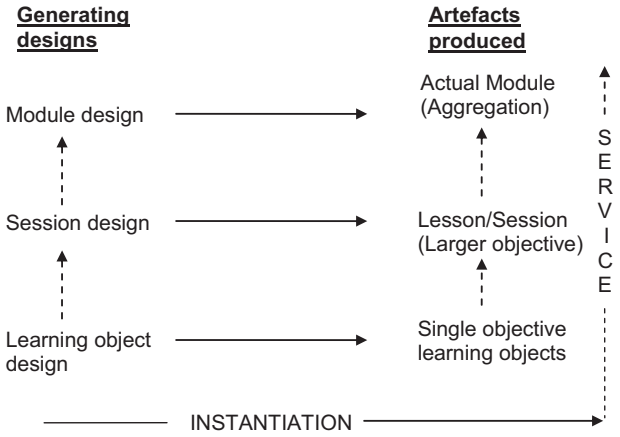

Fig. 2. A simplified view of the integrated 'layers and service' model (from Boyle, 2010a).

The terms 'Single objective', 'Larger objective' and 'Aggregation' are derived from the ALOCOM reference model (Verbert, 2008; Verbert & Duval, 2004).

This reference model was devised in particular to deal with concerns about the problems of reuse and re-integration of educational resources (both designs and learning objects). This is a major issue given the extensive work on promoting the release and uptake of Open Educational Resources (OERs) (e.g. Academy/JISC OER, 2011; Boyle, 2010b). The model aims to map particular educational resources in terms of their nature ('design' or 'product/artefact') and layer of operation. It seeks to encourage maximum flexibility in design so that entities at one layer (e.g. learning objects) provide a service that can be flexibly used at the next layer up (the containing context).

This framework highlights 'basic level' learning contexts that operate below the conventional class/session layer. There is a lot of work at this level under the umbrella of reusable learning objects. Boyle (2003) treats these learning objects, each focused on one clear learning goal or objective, as 'micro-contexts' for learning. The 'learning object', he argues, once activated by the user becomes an active learning context, which, in turn, is automatically (and unavoidably) embedded in the local eliciting context. Boyle (2003) sets out principles for designing these micro-contexts to maximize ease of integration into a variety eliciting contexts, such as formal classes or home study. These design principles focus on creating the micro-context as a self-contained open educational resource (OER), that can be flexibly integrated into different teaching and learning 'container' contexts. It does this by explicitly minimizing the 'couplings' between the micro-context and its original eliciting contexts on order to maximize the opportunity for integration into new eliciting contexts.

In this way the basic learning object layer provides a service for flexible reuse and integration at the next highest layer. Most material put on repositories as OER was not developed to have this service architecture. Educational resources with numerous couplings into original eliciting contexts (and fuzzy boundaries across different contextual layers) make effective reuse and integration into new contexts problematic. Viewing education as a clean set of contextual layers, where lower layers provide reusable services to higher layers, provides an architectural framework for more effective OER.

5. Designing and communicating about contexts for learning

Hodges and Sasnett (1993) provide an interesting comparison between film theory and educational multimedia design. They compare context to a scene in a film. The crucial difference is that we are passive observers of a scene but are active contributors in contexts. The design of a scene involves the internal unfolding of the scene (mis-en-scene), and the relationship of the scene to the rest of the film (montage). This is a useful perspective to apply to context. We have looked at 'montage' in relation to contexts for learning in the first half of this article. It is now time to focus in more detail on how we may deal with the internal aspects of effective learning contexts.

Design centrally concerns the nature of the learning task, the learning activities, the resources used, and feedback on progress towards achievement (Fig. 3). Where do we derive knowledge and insights to guide the design decisions about these features? Hammond (1993) argues that psychology has revealed considerably more about the contextual factors that influence learning than about the underlying cognitive processes involved. The role of the learning technologist is then to exploit this knowledge from psychology and the social sciences to design contexts that promote effective learning. The technology provides affordances and constraints in the type of contexts that we can create (Boyle & Cook, 2004; Conole & Dyke, 2004). However, the deep design of these contexts for learning should be driven not by the technology but by principles for enhancing learning derived from the relevant disciplines.

This design knowledge may be represented in different ways. The most general is in terms of principles and heuristics for learning. The constructivist and situated learning traditions with their rejection of 'over prescriptive' instructional design tends to be strong in this area (e.g. Herrington et al., 2010). However, there have also been strong movements towards trying to capture learning designs in more structured forms, so that these designs can be captured, stored and reproduced, e.g. as scripts. These approaches are considered in the following sections.

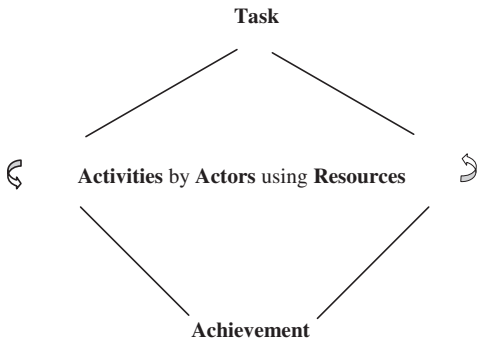

Fig. 3. Elements of contexts.

5.1. Principles and heuristics for authentic learning contexts

Principles and heuristics derived from the learning sciences provide important insights into understanding the problems that the learners face. They also suggest design features that may facilitate and empower learners to achieve learning goals. Design requires not just a construction of the overall learning context, but detailed concern with the tasks, the activities of learners, and the means of knowledge representation used. We need to weave these into a learning context in such a way as to enable learners to succeed where they might otherwise fail.

The traditional approach in formal education, especially in higher education, has been criticized for creating artificial classroom contexts where the learning activities and resources become divorced from their meaning in real life situations (e.g. Herrington et al., 2010; Schank, 2011). The advocates of "authentic learning" argue for the creation of more meaningful learning situations. "Authentic learning" requires that the contexts used for learning reflect real world contexts where the skills and competencies will be deployed. These scenarios can cover a wide range of domains from role play negotiation through to accessing real (but expensive) scientific instruments over the Web to conduct more realistic experiments.

The design of learning contexts may involve principles such as:

- Setting engaging and authentic tasks (e.g. Herrington et al., 2010);
- Appropriate and effective use of representational media (e.g. Boyle (1997);
- Learner control, with appropriate scaffolding support (e.g. Luckin, 2010)
- Productive feedback on errors (e.g. Papert, 1993)

As Lombardi (2007) points out, authentic learning is not new. She situates it as the primary mode of learning in traditional work-based apprenticeships. She sets out ten design principles for authentic learning from the use of ill defined tasks with multiple possible solutions, through sustained collaborative investigation, to the production of meaningful 'polished' products (Lombardi, 2007).

The essential message of "Authentic learning" is to create contexts that are meaningful and engaging for learners as opposed to the didactic, disembodied teaching contexts that are so common in formal education. This tradition provides a rich set of design principles for creating complex, engaging learning contexts. It is not the place here to go into a detailed exposition of these principles. Herrington et al. (2010) and Lombardi (2007) go through these in detail. They also provide a wide range of examples of authentic learning scenarios, with interesting further examples provided by Schank (2011) for MBA education through interactive scenarios and Wills and McDougall (2008) in the use of complex, role play simulations.

5.2. Representing reusable designs: templates, scripts and languages

There has also been considerable interest in capturing and representing "learning designs" in more formal ways. These formalisms are designed to capture successful designs and store them in repositories so that they can be widely accessed and re-used. This approach provides the potential to articulate, communicate and reuse explicit representation of "successful" designs. Below we consider three approaches: scripts, descriptive language frameworks, and generative learning designs.

Scripts: arguably the most common conceptual form for representing the unfolding of contexts is that of 'scripts'. This idea was elaborated as a form of knowledge representation in Artificial Intelligence (AI) where it was developed to give a representation of event-based phenomena (Schank & Abelson, 1977). In a simpler form it underpins an extensive, practical body of work on how to capture, store in repositories, and reproduce 'learning designs'.

The scripts are usually based on templates. A range of projects use this template based representation for learning designs (e.g. ALTC, 2011; EnROLE, 2009; Wills & McDougall, 2008). These scripts are structured under a set of headings for describing learning/teaching designs. For example, the ALTC (Australian Learning and Teaching Council) repository uses a standard template with headings for:

- roles (teacher, student)
- activity,
- resources,
- learning outcomes,
- assessment strategy (ALTC, 2011).

This aims to capture how *people interact* with each other and *resources* to achieve target *learning outcomes*. The narrative is captured as an augmented script, which is stored in the ALTC repository. These scripts are searchable by teachers who may download the script and re-create the designated learning context.

There is a major impetus towards making learning designs freely available through the Web (Sampson, Zervas, & Sotiriou, 2011; LAMS, 2012). The learning design movement extends the range of the OERs (Open Educational Resources) movement to the design level. There are, however, a number of challenges for script based approaches. As in the OER movement in general, there is little quality control. The emphasis is on encouraging a wide range of submissions rather than on limiting submissions through judgement of pedagogical quality. A further issue is the "type-instantiation" problem discussed earlier in the article. These script-oriented approaches give quite high level descriptions. It can be challenging to get from script description to instantiation. The descriptions need to be relatively concise, and this may leave a number of issues that need to be resolved by the teacher. Wills (personal communication) uses the descriptions as an initial shop window, and encourages direct communication with the script originator. Another potential solution to the type-instantiation problem is to have executable scripts – this issue is returned to later.

Descriptive modelling language: a more formal and complete approach to describing learning designs is provided by IMS LD (2003). The IMS specification provides a standard way of describing teaching and learning designs. It aims to provide a 'neutral' modelling language where the design for any teaching/learning context can be described in a formal way. This formal description aims to provide the basis for interoperability, as the descriptions, captured as XML files, could be read by any client that conforms to the IMS LD specification.

IMS LD explicitly adopts the metaphor of a Play as a framework for describing the basic elements in a design. These basic elements consist of: roles, activities and environment. People adopt certain roles (e.g. teacher, learner), to conduct activities in an environment that provides resources (e.g. a discussion forum) in order to achieve certain outcomes (Koper & Miao, 2008). IMS LD is more general, in that it aims at a general language for describing designs rather than a list of template based scripts. One issue of interest here is the use of the metaphor of a 'Play'. The 'Play' metaphor provides a framework for an attempt to formally describe 'contexts for learning'. Metaphors alone, however, are not good enough. The aim of the article is to go beyond metaphors to try to understand more fully what we mean by contexts for learning.

IMS LD is not concerned with deep learning design. It explicitly sets out to capture any learning design no matter how good or how poor it is. The IMS LD quest for machine readable, interoperable descriptions, also led this work in a highly technical direction, where pedagogical concerns become increasingly secondary to considerations of interoperability. It deliberately simplifies context so designs can be executed, and in doing so, arguably creates artificial contexts that are divorced from the richness of real contexts. This approach might provide a mechanism for capturing learning designs, but it has little to say about deep learning designs per se.

Language inspired generative representation: initial work underlying this approach concerned the development of multimedia learning objects – where the learning objects were explicitly treated as micro-contexts for learning (Boyle, 2003). These micro-contexts, which focus on one learning objective, provide a base context for learning. They are explicitly designed to facilitate reuse and embedding in different teaching/learning contexts (Boyle, 2003). Learning objects developed in this way won a European Academic Software Award in 2004. Over 200 learning objects based on this approach were developed by the Centre for Excellence in Teaching and Learning (CETL) in Reusable Learning Objects (RLO-CETL, 2011).

The GLO (Generative Learning Objects) work took this approach to a higher stage. This approach provides a framework, with tool support, for designing and instantiating these virtual micro-contexts for learning. This generative approach is based on linking function and form. The theoretical basis for this approach is provided by Systemic Grammar (Halliday, 1975) with its emphasis on deep structure function mapped to surface structure form. The deep structure design is expressed as the selection, refinement and sequencing of *pedagogical functions* (e.g. 'orient', 'comprehend', 'construct'). These functions are then mapped to the surface forms of screen layouts and media use. The GLO Maker authoring tool structures and supports this process. The GLO Maker website http://www.glomaker.org provides demonstrations on how this works (GLO Maker, 2012).

GLO Maker is of interest for two reasons: it employs an explicitly generative approach to the design and realization of virtual contexts for learning, and the design is placed within an explicitly layered approach. These granular learning objects are designed for maximum freedom of use at the next level of context (e.g. a session or class).

LAMS provides an executable design approach at a higher level – i.e. sessions or online classes (Dalziel, 2003). The generative approach is based on the selection and sequencing of tools for presentation, discussion, etc. (here function is equated with tool). The details of the use of each tool are then specified. The completed design is then automatically instantiated as a Web-based learning session using the LAMS delivery infrastructure. LAMS has attracted an extensive community where LAMS designs are communicated and shared (LAMS, 2012).

The advantage of the executable design approaches is that they bridge the type-instantiation problem. Design patterns lead directly to online instantiations. One design can generate a large number of instantiations through choosing options in the design, and through inserting content. However, not all designs can be rendered as online virtual contexts. More open and 'inspirational' designs require interpretations by teachers as mediators who then structure and elaborate the learning contexts. Executable learning designs, for all their advantages, are not applicable in a range of learning situations.

6. Summary and final reflections

Conceptual clarification is essential if we are to establish a stable and deep discipline of technology enhanced learning. Design for learning can be disrupted by the incessant waves of technological change. The technology is alluring; this can distract from deep design in a rush to exploit the surface features of the latest technology wave. This article argues for *deep learning design* where imaginative design principles are applied to the technological possibilities rather than being determined by them. This requires a unit of organization that is stable across technological change. This unit should give access to a rich range of imaginative design principles. The unit proposed in the article is that of 'context'.

This concept occurs repeatedly in the literature; yet its definition and articulation remain elusive. A central theme of this article is thus to explore and articulate a clear conceptual understanding of what is meant by "context". This provides an essential foundation for articulating principles of deep learning design. The nature of context is explored through a range of work. It is argued that our understanding of "context" relies on a shared, gestalt interpretation that enables us to recognize cues, make relevant contributions, and co-ordinate our

contributions. Such shared understandings could be built through mechanisms such as Vygotsky's zone of proximal development (Vygotsky, 1962), though it is not the focus of this article to explore this genesis. The instantiation of the contextual narrative is then viewed as an actively achieved, two-sided process which weaves a coherent field of activity based on the co-ordination of these intersubjective understandings.

Although the discussion of context may seem conceptual and abstract, we can move to a much more practical level. The practical implications concern the design of contexts that are engaging and effective for learners. As Hammond (1993) points out, Psychology has revealed a considerable amount about the contextual factors that influence learning. We can deploy this knowledge in our design of effective contexts for learning. Formal education often fails to do this. It imposes institutionally framed contexts (such as lectures), which are often divorced from the contexts in which the knowledge and skills are used (Schank, 2011). Movements such as "authentic learning" provide a range of principles and heuristics for the simulation of real world contexts. Mobile and ubiquitous learning emphasize the richness of learning in everyday informal contexts. There is not room in the article for an extensive review of these ideas. The important point is the availability of these rich sources of ideas for designers of technology enhanced learning contexts.

There is also considerable work on capturing and representing "learning designs" in more formal ways. These formalisms are designed to capture successful designs and store them online so that they can be widely accessed and re-used. The article reviewed several approaches, including scripts, descriptive language frameworks, and generative learning designs. These sources provide a rich base for designing contexts for learning. Executable learning designs link the design directly to online implementation. This provides working exemplars of the design. Inspirational learning designs have a greater gap between design description and instantiation. There may be considerable work for the teacher to interpret and implement these designs. There is always a gap between prototypical design and actual instantiation.

The primary argument of this article is that we should engage in reflective "deep" design. The process should be informed by appropriate principles, heuristics and designs representations. Design is always a creative process. The technology provides tools and resources; the essential imaginative ideas should not be driven by the technology but mapped to it. In this way we can establish a stable base for TEL design that is not dependent on specific technologies. As new, more powerful technologies become available we will then be better equipped to exploit their functionality.

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