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Designing Complex Systems for Informal Learning and Knowledge Maturing in the 'Web 2.0 workplace'

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Abstract: This article presents an original approach to designing complex systems to realise informal learning and knowledge maturing that is being conducted as part of a large-scale EC project called MATURE. In addressing the challenge of designing work integrated Technology Enhanced Learning (TEL) systems within the 'web 2.0 workplace', we have developed and tested an agile and 'federated' approach to the design of complex social and semantic technologies. This follows a paradigm of *Deep Learning Design* that incorporates: early technical and conceptual *Design Studies*; *Use Cases* of envisaged scenarios; *Demonstrators* which synthesise the technical and user requirements; and, a flexible *Evaluation Framework* that coordinates the related activities. After presenting this approach and how it is realised in an ongoing project, we offer some conclusions about designing complex socio-technical systems for TEL in the future.

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1. Designing complex TEL in the Web 2.0 Landscape and Beyond

How do we design the next generation of social and semantic technologies for Technology Enhanced Learning (hereafter TEL) that move beyond social networking and media sharing to, instead, mediate new and powerful learning processes interlinked with our everyday digital behaviour? And in pursuing this, how do we address the related challenge of designing in Agile ways, to address contemporary problems or opportunities through embedding technologies into existing digital practices. To address these challenges, a large-scale EC funded projects called "MATURE: Continuous Social Learning in Knowledge Networks" is exploring a new and somewhat radical approach to design. This has adapted principles of agile software development as expressed in the agile manifesto: (a) individuals and interactions over processes and tools, (b) working software over comprehensive documentation, (c) customer collaboration over contract negotiation, and (d) responding to change over following a plan. However, we have had to transpose these principles of agile software development to make them relevant to a large-scale integrating research project of a distributed and interdisciplinary nature, through incorporating them within a new paradigm of *Deep Learning Design* (Ravenscroft & Boyle, 2010).

This approach is supported through recent research on 'Social Software, Web 2.0 and Learning' (Ravenscroft, 2009). This has shown that it is very difficult to introduce radical changes in technology-mediated learning practices, and instead we should aim to build upon existing but evolving digital practices that can be reconfigured and enhanced, through technology, to achieve new and relevant forms of learning and meaning making. These ideas, that are quite general, can also be focussed on particular problems and contexts, such as in our case, where the challenge is of promoting *informal learning* and *knowledge maturing* in the 'Web 2.0 workplace'. The cornerstone of this initiative is an empirically derived conceptual model (of knowledge maturing) that we introduce below, before describing the design processes for developing the technologies that support it.

1.1 Informal Learning and Knowledge Maturing

According to Schmidt (2008), within contemporary work-places and enterprises, new perspectives bring together traditionally separated disciplines like e-learning, knowledge management, and HR development. This requires a fundamental change of the culture of the respective enterprise towards an enterprise 2.0, which is characterised by *enhanced collaboration* and a culture of *employee participation*. This means we have to rethink our understanding of learning and broaden our

perspective particularly towards *informal learning* activities (Schmidt, 2008). This is the broad focus of the MATURE Project, that is built around a model of knowledge maturing (Maier & Schmidt, 2007), where this is understood as "*the advancement of knowledge (i.e. learning) on a collective level and where it becomes less contextualized, more explicitly linked, and easier to communicate"*. The model organises this into a process of five phases: 1) *Expressing ideas*, in which new ideas are developed by individuals from personal experiences or in highly informal discussions, 2) *Distributing in communities*, in which a common terminology that is shared among community members is developed, 3) *Formalizing*, in which hitherto created artefacts are transformed from being inherently unstructured to being more purposive and structured, 4) *Ad-hoc learning*, in which material is prepared in a pedagogically sound way, enabling broader dissemination, 5) *Standardization*, in which individual learning objects are put together to cover a broader subject area, and thus become teachable to novices.

This complex, socially situated and evolutionary model clearly needs an original approach to design, that is agile and socio-technologically sophisticated, whilst accommodating the co-evolution of human behaviour and the development and use of social and semantic technologies. Hence, we followed the new paradigm of *Deep Learning Design* (Ravenscroft & Boyle, 2010) that is a combination of Design Based Research (e.g. see Design-based research collective, 2002) and Action Research approaches that is particularly focussed on designing TEL in the Web 2.0 landscape and beyond.

2. Design Based Research and Deep Learning Design

Our initial inspiration for a suitable design approach was evolutionary prototyping within a Design-based research framework.

According to the Design Based Research (hereafter DBR) Collective, in a seminal issue of *Educational Researcher (2003):*

> "The challenge of design-based research is in flexibly developing research trajectories that meet our dual goals of refining locally valuable innovations and developing more globally usable knowledge for the field." (Design-based research collective, 2002)

This approach is particularly relevant to our project, as we are exploring and aiming to promote and realise learning as a process of knowledge maturing in particular workplace settings, and also uncover more general insights about informal learning and knowledge development. Specifically, this involves developing a Personal Learning and Maturing Environment (PLME) and an Organisational Learning and Maturing Environment (OLME) that will be developed and used within particular workplace settings (e.g. Careers Advice in the UK and Training for the Construction Industry in Spain). And more generally, we are developing a generic framework – a model of knowledge maturing that can potentially apply to the continuous development of knowledge, informal co-learning practices, and greater mutual understanding within many, or most, knowledge worker contexts.

However, there were additional aspects our design problem that a pure DBR approach could not fully encompass. This is unsurprising as DBR is a somewhat diffuse set of methods usually deployed to perform Educational Research in general that is not specifically tuned to the particular features of our evolving digital landscape. In contrast Deep Learning Design (hereafter DLD) is more clearly articulated to address designing TEL within the shifting digital learning landscape, through prescribing an approach to learning design that includes: theoretical or conceptual foundations; foregrounding *design* as the key development concept (rather than specific emerging technologies); development and interaction in context; and, the adoption of evaluative frameworks linked to the conceptual foundations and authentic usage scenarios. The way in which this approach has been adopted in the MATURE project is described more fully in Ravenscroft et al., (2010). In the following Sections we drill down into a design strand that operates according to this approach in the context of our project, and its challenge of designing the next generation of 'social software for the workplace', which requires addressing the reality of harmonising bottom-up and top-down design processes in ways that can be technically realised through a Service Oriented Architecture (SOA) framework, or similar but more lightweight approaches.

3. Design Studies, Use Cases and Demonstrators

The MATURE project has adopted three key techniques to realise its design processes according to the principles of DLD, namely Design Studies, Use Cases and Demonstrators, and where these are coordinated through an overarching evaluative framework (Ravenscroft et al., 2009).

3.1 Design Studies

The Design Studies were early and critical 'experiments in design' that explored key aspects that needed to be validated prior to embarking on a full-scale design and requirements specification of the larger and more complex system. This involved establishing that the conceptual, user, and technical system design aspects of the project could all be covered and integrated. To ensure that this spread of concerns was addressed these studies involved technically oriented, conceptually oriented and user oriented partners. The design studies also took into account aspects that were emerging from an ethnographically informed study that was being conducted in parallel, with international knowledge workers, and we also included directed input in the form of scenarios from application and user partners (e.g. Careers Advisors in the UK and Construction Industry Trainers in Spain). This allowed 'in vivo' synchronization between the key perspectives of the project. So the goals of the Design Studies were, in the context of a focussed area, to: get feedback on initial ideas; discover integration potential; gain experience with supporting knowledge maturing processes; and by implication, elicit any early warning signs that needed to be considered and addressed as the project progressed. Practically, they were: focused and time limited; based on existing tools with limited further developments; incorporated both conceptual and software development foci; and, provided a mechanism to work, and initially build relationships with 'real users' at an early stage of the design cycle. These design studies that are summarised in Ravenscroft et al., 2009, were:
DS1: A Semantic media-wiki for maturing career guidance knowledge in use;
DS2: A Knowledge Maturing Dialogue Game (SoboLeo-InterLoc mashup);
DS3: Interacting widgets and integration;
DS4: Freefolio – A Personal Learning Environment based on WordPress;
DS5: OLMEntor - A demonstrator for the organisational learning and maturing environment;
DS6: Work-integrated Learning and Knowledge Maturing;
DS7: KASIMIR - pattern-based task management;
DS8: People Tagging for Collaborative Competence Development.

An evaluation of these design studies showed that they demonstrated, collectively, that all key aspects of the knowledge maturing design initiative were covered, namely - conceptual, technical and user (individual and community) aspects. Additionally, they covered all the phases of knowledge maturing except that last one, *Standardization.* But this was anticipated, as the earlier stages hold greater interest, especially 1. *Expressing ideas*, 2. *Distributing in communities*, and 3. *Formalizing*, as these are the processes not supported by existing knowledge management or e-learning tools. It was also interesting and positive to note that there was frequent coverage of *semantic maturing of content* and *collaborative and social activities for maturing*, which demonstrated as a whole, that the design studies investigated *content*, *process* and *practice* aspects of knowledge maturing. These studies also highlighted, at an early stage, the difficulties of clearly differentiating the functionalities of an OLME and PLME.

Having performed this initial 'health check' of the design activities across the project, the next step was to more thoroughly locate design activities within concrete user scenarios and develop applications within focussed interdisciplinary teams, of technical developers, conceptual experts and users. This necessitated a 'language of design' that could be shared by the interdisciplinary teams and communicated externally, so an elaborated and specialised Use Cases technique was developed.

3.2 Use Cases and their Suitability to the Challenges of MATURE

To represent the bottom-up and user-oriented nature of relevant technology-mediated activities we developed a comprehensive set of (twenty seven) Use Cases. These were elaborated to incorporate the conceptual model (of knowledge maturing) and the findings from an ethnographically informed study (such as typical user *Personas*). These were then also linked to technical requirements that realise the functional goals of the Use Cases.

According to Bittner and Spence (2002), a Use Case represents the views of different stakeholders in the design process and documents designs. They are a reason to use a system and are usually a collection of possible scenarios related to a particular goal. A Use Case is written in high level yet concrete language and describes the system from an actor's point of view. Actors may be end users, other systems, or hardware devices. Another key aspect of Use Cases is that they are testable, in the sense that their post conditions can be judged as satisfied (or not). In the first instance the Use Cases are usually independent of the technical implementation of the system, but they can subsequently be elaborated with technical requirements that realise them. This means that Use Cases can be used as a core representational scheme that evolves during the stages of the software development life-cycle. It is argued that development teams who effectively employ use cases deliver better applications - on time and under budget (Bittner and Spence, 2002).

From the definition above we can see why the Use Case technique is particularly relevant to the challenges of our project. Firstly, they (somewhat obviously) foreground the role of users in designing user-system interactions. Secondly, they are deliberately aimed at providing a shared format for representing the views of different stakeholders (e.g. users, conceptual experts, developers, managers). Thirdly, they are design documents that can be retained throughout the software development life-cycle. So initially they specify requirements and then as they evolve they document the system designs. Fourthly, they allow for the transition from systems analysis to technical realisation through elaborating the actual Use Case (e.g. with technical details and service descriptions). Fifthly, because they rely on using precise but natural language (with the exception of the technical realisation aspects), all stakeholders are able to be actively involved in the design process and understand it. And finally, whilst relatively formal they are also extensible and flexible, so we can elaborate a standard template with features that are of particular interest to MATURE, such as *Phases* of maturing and the *Personas* (from the ethnographic studies), features of knowledge maturing and whether they are ostensibly relevant to a PLME, OLME or both. So typical Use Cases that represent our design, in addition to their standard structure, typically include: the specific Design Study that inspired their production; a category of Persona, or Personas, involved (that were derived from empirical studies); and, the Phase, or Phases of knowledge maturing that they correspond to.

Top-down and strategic coordination of the Use Cases was realised through clustering the individual cases according to key activities, or *Areas* for knowledge maturing. These are:
Area I. Learning by searching for and exploring artefacts for the task at hand;
Area II. Learning by finding and communicating with people;
Area III. Becoming aware of developments and changes;
Area IV. Creating, refining, developing, aggregating, structuring, and sharing artefacts;
Area V. Reflection and Gardening;
Area VI. Creating a learning environment.

For example, the second Area, *Learning by finding and communicating with people focuses on* improving knowledge maturing by improving direct contact between people. This is particularly important for knowledge for which there are no artefacts of sufficient maturity (yet), and also for forming groups in which maturing can happen. The Use Cases for this Area are (where the identifier on the left consists of the maturing area covered, in roman numerals, followed by the number for where it is in the list of the cases for that area):
UC II.1 Finding people;
UC II.2 Tagging people;
UC II.3 Communicating with people;
UC II.4 Forming groups;
UC II.5 Supporting context-sensitive dialogues.
UC II.6 Fostering maturing of artefacts through dialogues

To summarise, this Use Case methodology emphasises: the reality of, and variation in, 'real people' using the tools; the interaction of users (i.e. actors) with the software system to perform actual tasks; and, the linking of interactions to predominantly social knowledge maturing processes and activities.

3.2.1 Linking Use Cases to Demonstrators of Knowledge Maturing

Unfortunately the design challenges for MATURE could not be completely covered by the Use Case technique. The nature of the design and requirements for the software that MATURE is developing, which is interlinked with complex and contextualised knowledge worker practices and social behaviour

cannot always be pre-specified. Instead, many requirements emerge 'in action' during tool use and inform development in an incremental way. Therefore we needed tangible but evolving technologies that realised the Use Cases whilst still operating within the agile development framework that the project required. Consequently, we linked the Use Cases directly to the development of four Demonstrators that addressed concrete knowledge maturing scenarios. These *Demonstrators linked to the Use Cases, User Scenarios and end-user feedback*, are 'live' and *evolving designs* that collectively cover the key socio-technical aspects of the project, namely *content, people, semantics* and *processes*. For example, Demonstrator 2 (see below), which focuses on 'The Collaborative Development of Understanding' addresses the following Use Cases:
UC II.6 Discuss about artefacts in structured and traceable dialogues;
UC IV.1 Collect and structure artefacts and share collections;
UC V.6 Garden shared vocabularies;
UC V.3 Reflect on one's own contributions to organizational knowledge development.

3.3 The Federated set of Demonstrators

So, our current MATURE design consists of a set of Use Cases clustered according to areas corresponding to the model of knowledge maturing, that are then linked to specific Demonstrators that realise them. These Demonstrators are described below based on descriptions given in Bradley et al (2010).

Demonstrator 1: Assuring Quality for Social Learning in Content Networks
The objective of this demonstrator is to actively support social learning in a distributed setting, where the extent to which this was achieved was analysed and tested within the context of Career Services. The aim is to support knowledge workers in sharing their knowledge and experience and also foster informal, work-integrated learning when dealing with rapidly changing information, such as Labour Market Information in the context of Career Services. The quality assurance process relates to: the personal need for an adviser to find appropriate and up-to-date information as fast as possible for the current work context; and, the organisational need of achieving a coherent and high quality organisational identity in the development of knowledge artefacts. These are achieved by providing indicators for quality assurance, providing access to an overview of the knowledge base and by providing possibilities for gardening the knowledge base.
Demonstrator 2: Collaborative Development of Understanding
This demonstrator supports a community of practice in developing a collaborative understanding of their domain by interweaving the development of a shared information repository and vocabulary (ontology) with dialogues about them. The linking of social bookmarking 'in action', the collaborative and open development of ontologies and the included semantic relations, and aligning dialogue and semantics addresses a number of important research challenges. These include how to improve the understanding, maintenance and application of ontological schemes to contextualised problems within work-based communities.
Demonstrator 3: People Tagging for Organizational Development
This demonstrator primarily addresses, from an end user point of view, the problem of finding the right person to talk to. It allows for sharing the "knowing who" within a group or community via a collaborative tagging approach to gather information about persons. This information can also be used in human resource development situations that need to have sufficient information about the needs and current capabilities of existing employees in order to make the right decisions about the training required.
Demonstrator 4: KISSmir - Maturing process knowledge and learning by case tracking and mining
This KISSmir demonstrator provides guidance to users in performing tasks by workflow and task pattern support, e.g., by suggesting tasks or appropriate resources. However, it leaves the users the freedom to execute the task in a way they like and to add resources and procedures that they prefer. KISSmir also allows users to make their experience publicly available for other users working on similar tasks. In this way KISSmir supports the process maturing at the personal and organisational level.

3.3.1 Development and interaction in context

All stages of development of the MATURE Demonstrators are performed by design teams including technical and user-representatives, who are addressing an authentic problem or opportunity in their

work-based contexts, such as Careers Advice (the UK Connexions organisation) and online training (a software company called STRUCTURALIA in Spain). Also fundamental to MATURE is the emphasis on, often creative and open-ended, social and collaborative processes within these authentic work-based Communities of Practice (CoP). All of the current Demonstrators, at a high-level, can be conceived as a means to harness or catalyse interactive knowledge maturing processes involving individuals, social and semantic software tools and a work-based CoP.

3.3.2 Evaluation approach and initial findings

These Demonstrators are all undergoing a combination of contextually tailored and common evaluative methods. This evaluation framework (Ravenscroft et al., 2009) assesses the Demonstrator applications in terms of the degree to which they solve a problem scenario, their usability within the user groups and the degree to which they support learning as knowledge maturing. A first phase of formative evaluation linked to participatory design activities has been completed (Bradley et al., 2010). These have typically led to the specification of concrete and acceptable user-system scenarios and refined user interfaces that will collectively support longer and more embedded knowledge maturing activities.

4. Conclusions for Designing Socio-Technical Systems

In this Article we have justified and presented a methodology for developing complex socio-technical TEL systems, with the particular aim in our case of promoting informal learning and knowledge maturing amongst knowledge workers in the contemporary workplace. The resulting methodology is unashamedly sophisticated, as we have genuinely wrestled with the reality of conjoining the latest generation of social and semantic technologies, user-intensive design processes, and embedding in authentic user scenarios. Our approach will be tested, ultimately, by the performance of prototypes that aggregate the functionalities and behaviours that our Demonstrators currently realise. However a clear message for designing complex socio-technical systems has already emerged from this work. Future TEL systems will always co-evolve with related human learning practices, so development, use and evaluation will be a continuous and ongoing process, and no longer conceived as predominantly discrete steps towards a 'final' design.

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