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Enriching Representations of Work to Support Organisational Learning

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Enriching Representations of Work to Support Organisational Learning

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1. TECHNICAL SUMMARY OF ENRICH

> "Businesses spend up to $100 billion each year to train workers. Yet estimates are that less than 10% of this training transfers to the job. So business wastes $90 billion each year...."
> [Review on US training effectiveness (Detterman 1993)]

Current theories of learning reveal why this is so: the process of acquiring knowledge cannot be separated from the process of applying it. Integrating working and learning is not a desirable luxury – it is a fundamental requirement for businesses to remain competitive. We will build on our existing technologies supporting web-based collaboration, learning-on-demand, and knowledge modelling, to develop tools and methodologies for integrating working and learning within knowledge-intensive organisations. Specifically, our tools and methodologies will support organisational learning within operational areas relevant to the industrial partners. The key business objectives that our approach will address are:

- Supporting individuals and groups to continually reflect on and improve their work practices, particularly in operational areas of planning and bid winning.
- Supporting distributed groups to share 'best practices' and improve their coordination efforts.
- Promoting the establishment of 'virtual centres of excellence' that serve to identify core competencies and nurture their further development by bringing people together (across time and geography) with relevant expertise.

These business objectives can be realised by viewing organisational learning as a process by which knowledge that is created during working is incrementally captured, structured, and maintained so that this *knowledge can be accessed or delivered when needed to inform individual and group work tasks.* Our learning approach integrates the full spectrum of learning needs – individual, group, and organisational – and is informed by the extensive experience of The Open University in distance education and open learning. We will enable organisations to realise these business objectives by providing tools and methodologies facilitating the cost-effective construction, and sustained use, of *knowledge-enriched intranets*.

The project's core technical objective is to integrate existing tools and technologies from the supplier partners (The Open University and TU of Kosice) to develop **The CEDAR Toolkit.** This toolkit will enable developers to provide customers with Contextually-Enriched Document ARchive systems containing:

- a document-centred discourse space for structuring discussions around representations of work;
- client tools enabling users to articulate and refine domain concepts by incrementally enriching their representations of work with related discussions and underlying knowledge models;
- knowledge delivery and access mechanisms supporting individual and group learning;
- an intranet-based organisational memory server for knowledge capture, structuring and maintenance.

Technology alone cannot ensure that learning takes place. The project's methodological objective will be the articulation of new work practices and roles needed to realise sustainable organisational learning within specific industrial settings. This objective will be assessed and refined by deploying and evaluating our technologies in naturalistic settings *throughout the project* within industrial groups by the user partners (TecInno, BAe, and DFKI). Specifically, to ensure that the tools and methodologies delivered by the project are both useful and usable, three pilot projects will provide the context for all implementation and evaluation activities:

(1) **The Team Workbook** – Fostering best practices through the intertwined teaching and use of planning methodologies such as Total Quality Management (BAe Virtual University within BAe)

(2) **The Experience Archive** – Assisting the sales force and engineers to share expertise through enriched product documentation archives (TecInno with JOLA)

(3) **ProGroup Electronic Manual** – Supporting wide area organisational learning using a proactive electronic group manual to integrate multiple group memories (DFKI with Saarbergwerke AG)

Our exploitation objectives are based on the dissemination and marketing of our software product deliverables (CEDAR Toolkit, Team Workbook, Experience Archive, ProGroup) and our consulting packs (workshop and course materials). These objectives build on the strengths of the user partners. TecInno and DFKI have extensive practical experience in delivering innovative technologies to industry through software development and their consulting arms. BAe's Virtual University, through partnerships with Airbus and Eurofighter consortia, will be well positioned to market the Team Workbook and consulting packs throughout the aerospace industry. The Open University, with the largest MBA programme in Europe, will be well positioned to market the course materials and introduce the ENRICH approach to the next generation of industry leaders.

2. PROJECT OBJECTIVES AND SCOPE

We begin by enumerating key learning processes that an integrated organisational learning approach must address. Next, we analyse the shortcomings of the current state-of-the-art from technical and cognitive perspectives. We then describe our technical and methodological objectives and conclude with our project strategy, describing the activities and expected outcomes from each of the three cases.

2.1. Nature of Workplace Learning

"Learning is the new form of labour" (Zuboff 1988) in a knowledge economy – it is absolutely vital that learning be effective and efficient. Yet, many industries rely on traditional 'school models' for most of their educational needs even though workplace learning is fundamentally different from traditional school learning (Table 1). Empirical studies of professional practice, by ourselves and others (Lave 1991; Sachs 1995; Sumner 1995), show that while the focus is primarily on getting the job done, learning is inextricably intertwined with working. In order to do their job, professionals must continually learn to apply existing knowledge to routine or innovative situations and to construct new knowledge in response to changing workplace situations. Thus, learning is fundamentally embedded in ongoing work activities and these work activities, in turn, give rise to the problems driving the learning that must take place.

Table 1. School Learning versus Workplace Learning

	School	**Workplace**
Emphasis On:	Learning basic facts and skills	Getting the job done
Ultimate Goal:	"Knowing"	Developing "Best Practices"
Knowledge:	Static, Decontextualized, General	Dynamic, Situated, Practice-oriented
Topics / Problems:	Given by curriculum	Arise from and embedded in work situation
Scope of Learning:	Primarily Individual	Individual, Group, Organisation

Our research is concerned with building computational environments integrating both working and learning. Our previous work focused on supporting individual learning (Sumner and Stolze 1996; Sumner, Bonnardel et al. 1997), and knowledge modelling (Domingue, Motta et al. 1993; Motta and Zdrahal 1996; Motta 1997) in centralised work settings. In this project, we extend these previous efforts to the *organisational level*, and provide support for the integrated spectrum of learning activities (individual, group, and organisational) in *distributed work settings*. Before looking at the state-of-the-art, we will examine current theoretical perspectives and empirical findings of individual, group, and organisational learning to enumerate key challenges which an integrated approach must address.

2.1.1. Individual Learning: Becoming Reflective Practitioners

In his seminal book, "The Reflective Practitioner," Schön (Schön 1983) describes an action-breakdown-reflection cycle that underlies professional practice. In this cycle, practitioners engage in situated action until their expectations are not met and they experience a breakdown in the current work situation. At that moment, practitioners stop and reflect on how to overcome the breakdown before proceeding. These breakdowns in situated action present opportunities for learning because there is an opportunity to construct new contextualized knowledge while solving a personally relevant problem (Fischer 1994).

However, detecting and overcoming breakdowns requires much skill and domain-specific knowledge. People newly hired into a workplace will often lack this necessary knowledge. Even "old-timers" can be challenged. In complex domains, no one person can possess all the knowledge necessary to complete a task (Rittel and Webber 1984). In dynamic domains, what constitutes "necessary" knowledge is continually changing. Practitioners, both old and new, need to continually learn and relearn how to: (1) recognise potential breakdowns, (2) identify knowledge relevant to the breakdown, and (3) apply this knowledge or construct new knowledge to overcome the breakdown.

– Key challenges for supporting individual workplace learning are to support reflection-in-action processes by helping practitioners analyse their work products and detect potential problems or opportunities. Systems need to deliver relevant information to practitioners that they may be unaware of to assist their reflections.

2.1.2. Group Learning: Becoming Communities of Practice

These days, teams and groups form the core work units in many industries. However, while teams themselves are widespread, examples of effective group practices are less so. The literature is filled with stories of dysfunctional group working practices (Curtis, Krasner et al. 1988; Grudin 1991). Studies reveal that effective groups are good at "perspective making" (Boland and Tenkasi 1995); i.e., they share customs, conventions and

standard practices that help to get the job done more effectively (Brown, Collins et al. 1989; Lave 1991; Sachs 1995). It is precisely these often tacit customs and conventions that form "best practices."

Our empirical studies of groups suggest that supporting communities to evolve their own vocabularies and to elaborate them to create a shared domain model is a critical step towards creating a common perspective (Sumner 1995) and an effective "community of practice." Shared vocabularies improve group communications; shared practices improve group coordination during complex tasks. Over time, as communities engage in negotiation and reflection about how to do their job better, their vocabularies and domain models become more elaborate and formal; i.e., their tacit understandings are articulated and refined towards more explicit knowledge forms. In many cases, they enrich their tools and work products with formal representations of their domain models in order to have better tool support for their work practices. The articulation and use of explicit domain models reinforce best practices by aiding the consistent reproduction and interpretation of work products. We refer to these processes of elaborating vocabularies, negotiating, and enriching as "domain construction" .

– A key challenge for supporting group learning is to support domain construction processes. Systems need to enable practitioners to articulate their informal understandings, to view and discuss their emerging ideas and domain models and, importantly, to incrementally modify domain models as their understandings change.

2.1.3. Becoming a Learning Organisation

Typically, organisations are composed of multiple interacting communities, each with highly specialised knowledge, skills, and technologies. Important tasks like product design and innovation in knowledge-intensive firms require these diverse communities to bridge their differences and integrate their knowledge and skills to create a new, shared perspective (Boland and Tenkasi 1995). Some researchers argue that this social sharing is the crucial first step towards knowledge creation (Nonaka and Takeucji 1995).

This bridging process is not so much one of passive 'sharing' as one of active 'perspective taking' and it is often complicated by the fact that a community's shared vocabulary or domain model is often tacit, making it uninspectable and difficult for another community to understand. Communities may share similar words and concepts at the surface level, but may actually be using them in entirely different ways (a phenomena dubbed 'ontological drift' (Robinson and Bannon 1991)) resulting in communication and coordination problems. Sometimes this bridging is further complicated by time – the critical experts are no longer with the company or are otherwise unavailable for collaboration. Supporting such long-term, asynchronous collaboration is particularly important in industries needing specialised expertise that also rely on mobile and flexible workforces. Ultimately for perspective-taking to be successful, shared objects and work products must be re-interpreted and assigned a shared meaning – a process that usually requires much debate and negotiation.

– A key challenge for organisational learning is to support perspective taking. Systems need to support knowledge sharing across workplace communities *and* across time. However, sharing knowledge is different from simply sharing information – people need support for interpreting each others' perspective and for negotiating a new, shared perspective.

2.1.4. Integrating Individual, Group, and Organisational Learning

Building on Argyris and Schön's definition (Argyris and Schön 1978), we define organisational learning as: (1) a process that takes place through the agency of the individual members, (2) where individual and group learning experiences become incrementally embedded in organisational memory. An integrated approach is necessary because one cannot support organisational learning without supporting individual agency. However, we extend their definition to take into account the different types of learning processes at each of the three levels; i.e. individual, group, and organisational. Table 2 summarises requirements for our integrated approach.

Table 2. Requirements for an Integrated Organisational Learning Approach

Scope	Learning Process	Requirements to Support Process
Individual: Within an individual work session	Reflection-in-action	• detecting potential problems or opportunities to improve work products • actively delivering new information to support reflection
Group: Within a community	Domain Construction	• articulation and elaboration of domain vocabularies and concepts • negotiation about emerging domain concepts • enriching of work products and tools with domain models
Organisational: Across Communities and Time	Perspective taking	• sharing of knowledge and work products • products linked with supporting context to aid interpretation and negotiation

2.2. State of the Art

Here, we examine the state-of-the-art with respect to the requirements outlined in Table 2. We begin by looking at an important type of structured discussion space, design rationale systems, which our approach builds on. Then we analyse related work in organisational memories, learning-on-demand systems, and intranet-based document management systems that CEDAR builds on.

Design Rationale. Design rationale systems provide structured discussion spaces based on various notations such as issues, pros, and cons (Conklin and Begeman 1988), and questions, options, and criteria (Buckingham Shum 1996). These systems assume that as practitioners work, they also add their reasoning and justifications to the system using the provided notation and thus create an 'organisational memory' as they work. Experiences indicate that design rationale systems can be very useful for supporting long-term asynchronous negotiation and collaboration across time (Fischer, Grudin et al. 1992). However, one weakness of this approach is the lack of support for context: often there is little integration between work products and discussions about the products. This separation results in a loss of necessary context for understanding and interpreting both the design rationale and the products (Ruhleder 1994). Integrating work products with their related discussion is also important for sustainability of the rationale repository; integration makes the repository easier to access during actual work, which in turn promotes making further additions to it (Fischer, Lemke et al. 1991).

Organisational Memories. Organisational memories are motivated by the desire to preserve and share the knowledge and experiences that reside in an organisation. As such, most systems focus on capturing the knowledge, storing it, and making it accessible, rather than explicitly supporting the creation of new knowledge. By themselves, organisational memories are a necessary but insufficient step towards organisational learning. Several analyses based on case studies (Ackerman 1993) and critiques from social and psychological perspectives (Bannon and Kutti 1996) conclude that maintenance of contextuality is of crucial importance for supporting learning or 'active remembering'. Likewise, the generic nature of memories that attempt to serve all needs across large organisations often inhibits successful location and interpretation of relevant information. Recent efforts are instead targeting smaller, more focused approaches such as task-based memories (Ackerman and Mandel 1997), methodology-based memories (Hidding 1997) and community memories that support the incremental evolution of both structure and content (Marshall, Shipman et al. 1994). These approaches are a positive step towards enabling organisational memories to support the learning needs of individuals and groups.

Learning on Demand. Many approaches to supporting learning-on-demand or just-in-time learning are divorced from actual work contexts and, instead, are embedded within traditional curriculum-driven educational models. Their emphasis is on using the Internet to support distance learning. Other approaches intertwining working and learning in design domains, such as critiquing systems, have proven effective in supporting workplace learning for both newly hired and experienced designers (Sumner, Bonnardel et al. 1997). The challenge for this type of learning-on-demand is to have a rich shared context between the user and the system in order to determine the user's potential information needs (Fischer, Nakakoji et al. 1993). Another crucial feature, particularly with regard to supporting reflection-in-action, is proactivity: systems need to point out potential problems at the 'right time' when practitioners are best able to take advantage of the provided information (Lemke 1990).

Intranet-based Document Management Systems. Intranets are the fastest growing segment of the Internet market. Intranets use World Wide Web technologies to support an organisation's internal information needs, which are often document-centred since documents permeate much of organisational practice (Brown and Duguid 1996). Such uses were heralded by pre-Web groupware products such as Lotus Notes™ (Orlikowski 1992). However, as recently noted by Xerox™ (with more than 200 servers and 20,000 users), "this internal Web, as an environment for supporting organisational work, is falling short of our expectations and hopes in significant ways" (pg, 81) (Rein, McCue et al. 1997). They found off-the-shelf intranet software to be most successful when deployed to support simple, well-understood work practices where the information was factual and did not involve interpretation. They advocated creating a new style of intranet, with support for document management roles. Similarly, we view systems such as Intranets and Lotus Notes as important generic enabling technologies that we can build on to create organisational learning systems, rather than end-points in themselves.

Analysis of these Approaches. Common shortcomings across many of the above approaches are passivity, lack of extensibility, and lack of context. The passivity of many approaches requiring users to search for relevant information in large memory stores limits their ability to support reflection-in-action. Several approaches lack extensibility which inhibits their evolution in the workplace to take into account new knowledge or work practices; i.e., organisational memories that are difficult for practitioners to extend. Such non-extensible systems cannot support domain construction processes underlying group learning. Finally, common among many approaches was lack of support for context, either to assist human interpretation and learning (i.e., the separation of design rationale from work product) or to support intelligent system interpretation (e.g., the necessity of shared context for learning-on-demand mechanisms). In the next section, we will describe how our approach towards supporting organisational learning addresses these shortcomings.

2.3. Our Approach: Contextually-Enriching Documents

> The core of our approach centres on enabling practitioners to progressively enrich their representations of work with important contextual cues and information arising from social discourse processes. A key contribution of our 'enriching' approach is to capture contextual cues and information in such a way as to *tightly couple* them with representations of work.

When discussing the critical role of learning in the new knowledge economies, Zuboff described 'smart machines' that could assist in actively 'informating' practitioners as they work (Zuboff 1988). In our view, it is not smart machines per se that serve to informate, but contextually-enriched documents since documents form the core of many business practices and are the objects that many practitioners work with daily.

In a recent study looking at document use by knowledge workers, Kidd found that the *process of articulating and refining work products* was often more important for informing practitioners than the products themselves (Kidd 1994). In a broader context, Brown and Duguid contrast two basic models of document use: 'documents as darts' where documents serve as a means of objectively transmitting knowledge and 'documents as a means for supporting social processes' (Brown and Duguid 1996). They argue that *a key role of documents is to support negotiation and interpretation as communities struggle to reach a shared understanding*. Likewise, several leaders in collaborative working and learning have argued for a re-thinking of the status of 'representations of work' (Bannon 1995; Suchman 1995). They argue that rather than regarding these work products as static accounts or descriptions of the way things are, *representations should be regarded as starting points for discussion about the way things ought to be* .

In our view, the key to integrating working and learning is to support these socially-based, process-oriented views of representations of work. As indeed, these processes derived from analyses of document use are the same as the processes underlying individual, group, and organisational learning: reflection, articulation, elaboration, negotiation, interpretation, and sharing.

The core of our approach centres on enabling practitioners to progressively enrich their 'representations of work' with important contextual cues and information arising from these social processes. Representations of work take on many forms, including project specifications, design solutions, project bids, planning documents, etc. In most organisations, these representations take the form of documents, usually in paper form and increasingly in digital form as they are published on organisational intranets. Contextual cues and information takes on many forms including discussions surrounding the document, shared vocabularies or practices underlying the document, relationships to organisational competencies, and other related or dependent work products.

While this contextual information is vital for supporting key processes such as interpretation, we argue that simply capturing this information is insufficient. A key contribution of our 'enriching' approach is to capture these important contextual cues and information in such a way as to *tightly couple* them with the representations of work. This enriching approach has three direct benefits:

- The richer context supports improved human-human communication and collaboration by keeping the context for interpreting a document coupled to the document itself.
- Enriching is a user-centred form of extensibility, encouraging practitioners to articulate their tacit understandings and incrementally refine them towards more explicit knowledge representations by reifying the context and its interconnections.
- The richer context makes possible active forms of computer support (i.e., learning-on-demand) by providing a richer machine-interpretable context.

2.4. CEDAR Toolkit and Methodology

Earlier, we discussed how organisational memory approaches based on the 'one-size-fits-all model' were problematic, resulting in memories that were too general to be useful or understood. Following our belief in the centrality of interpretation, we will focus on more specific forms: a large part of this project will be the creation of three task-specific instances of organisational memories based on our contextually-enriched document approach. Two key challenges for organisational memories are *cost effectiveness* and their *sustainable* integration into work practices. To meet these challenges, this project will develop a toolkit supporting the cost effective construction and customisation of task-specific memories, and a methodology guiding others in incorporating the memories into work practices to achieve sustained use and growth. We will develop an intranet-based architecture and an integrated toolkit (CEDAR) based on a central Contextually-Enriched Document ARchive server (the organisational memory) and distributed clients using our existing web-based collaboration, publishing, learning-on-demand, and knowledge modelling technologies.

CEDAR will enable (1) developers (information providers and knowledge engineers) to construct an initial organisational memory 'seed', (2) end-users to view and extend the memory contents, and (3) agents to deliver critical information at the right time to support reflection-in-action.

CEDAR relies on an organisational memory consisting of contextually-enriched documents. These hypermedia documents are work products enriched with related communications (e.g., structured on-line discussions), community coordination data (models of competencies), task or domain-specific models, and broader models of corporate values. We support publishing of hypermedia work products based on standard web-protocols and formats. To support learning while working, the CEDAR memory will be supported by client tools enabling:

Reflection-in-Action. Underlying knowledge models will be used to determine which parts of the memory are relevant to the current work context. Reasoning mechanisms will interpret and tailor selected knowledge to relate to the current task. This contextualized knowledge will be delivered to the user and presented in a way to enhance his learning processes. Consequently, the user can learn (a) from other members of the organisation or (b) from the store of previous organisational experiences. The user's results based upon learning while working are, in turn, fed back into the memory and preserved for future re-use.

Domain Construction Client tools will enable practitioners to enrich their hypermedia documents with links to knowledge models and communication traces stored in the CEDAR server as they work. The tools will support users to reify their emerging best practices by extending the organisational memory in two ways: (1) through on-line discourse coupled to work products and knowledge models, and (2) by extending knowledge models as their work progresses.

Perspective-Taking Practitioners will be able to share their expertise by exchanging contextually richer versions of their work products linked to underlying knowledge models and communication traces. This will assist interpretation and negotiation, enabling distributed work groups to comprehend each other's work and coordinate their activities.

The Open University (OU) is the main supplier of baseline technologies in this project. CEDAR will be based on the integration of existing toolkits, virtual discussion spaces, and modelling tools developed at the OU – the Digital Document Discourse Environment (Figure 1), OCML, and WebOnto. Crucial technologies from other partners (see Table 3) will be integrated into this baseline system in key areas: (1) underlying server technologies (TecInno and DFKI), (2) learning-on-demand (case-based reasoning (TecInno) and text analysis tools (DFKI)), and (3) reusable model libraries (TU of Kosice).

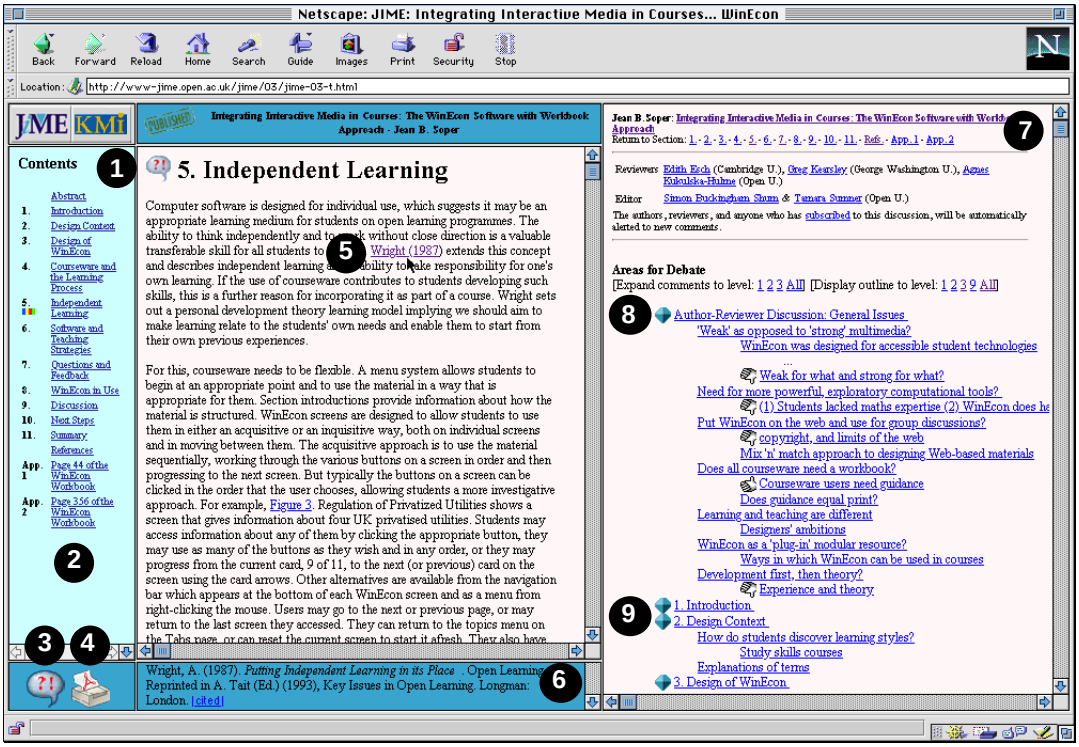

Figure 1: Automatically generated output from the D3E toolkit. On the left is the Article Window, on the right the Discussion Window shows a structured discussion about the document. Key: [1] Comment icon embedded in each section: displays section-specific comments; [2] active contents list; [3] icon to display top level discussion outline; [4] icon to download Acrobat version; [5] citation automatically linked to reference; [6] reverse link to citation; [7] links back into article; [8] general discussion headings defined in toolkit; [9] headings for section-specific comments.

Table 3. Overview of existing tools at Partners

Web-based Collaboration and Publishing Tools			
Tool (Supplier)	Funded By	Reference	Role in Project
D3E: Digital Document Discourse Environment (OU)	Open University, London Mathematical Society	(Sumner and Buckingham Shum 1998) http://d3e.open.ac.uk/ http://www-jime.open.ac.uk/jime/	D3E is a suite of technologies supporting the publication of web-based documents integrated into a virtual discourse space supporting structured discussions between distributed communities.
Learning-on-Demand Technologies			
Tool	Funded By	Reference	Role in Project
Pull Agents: CBR Answers (TecInno) Case-based Retrieval on the Web (OU)	TecInno ENCODE - EU Copernicus	http://www.tecinno.de/eindex.htm/ (Zdrahal and Domingue 1997)	A set of agents for locating and delivering previous experiences relevant to the current work product.
Push Agents: Critiquing Systems (OU)	U S WEST	(Sumner, Bonnardel et al. 1997)	Proactively delivers contextualized design knowledge supporting individual reflection and learning.
The Specialist Board (DFKI)	bmb+f SAP AG Daimler-Benz	(Baumann, Malburg et al. 1997) (Dengel and Hinkelmann 1996) (Junker and Hoch 1997)	Tool suite for classification, abstraction, and generation of natural language documents. Useful for information filtering and constructing contextualized responses.
Organisational Memories and Server Technologies			
Tool	Funded By	Reference	Role in Project
CBR–Works (TecInno)	TecInno INRECA I & II - ESPRIT	http://www.tecinno.de/eindex.htm/	A case-based reasoning WWW server system supporting HTML and Java clients. It is based on object-oriented domain models and can be used within the CEDAR kernel.
Electronic Fault Recording (DFKI)	Saarbergwerke AG	(Bernardi 1997) (Bernardi, Hinkelmann et al. 1998)	An integrated documentation and retrieval system for experience sharing and reuse. Will form a memory seed in the ProGroup Case.
Knowledge Modelling			
Tool	Funded By	Reference	Role in Project
WebOnto (OU and TU of Kosice)	HCReMa - EU Telematics	(Domingue 1998) (Zdrahal and Domingue 1997)	Enables ontologies to be collaboratively created and reused on the Web.
OCML (OU and TU of Kosice)	VITAL (ESPRIT II)	(Motta and Zdrahal 1996) (Hatala 1997)	An operational knowledge modelling language used to represent ontologies.

2.4.1. End-User and Developer Views of CEDAR

From the perspectives of end-users, task-specific memories creating using the CEDAR toolkit will have several common characteristics, including:

- a document-centred virtual discussion space enabling distributed communities to engage in debate and negotiation about their shared work products and their shared knowledge models. These discussions are tightly integrated with the work products, thus enriching the document with greater context.
- enriching mechanisms enabling them to extend knowledge models and interconnect models with specific documents and discussion threads, contributing to a richer document context.
- visible representations, such as concept maps, showing the current view of the structure of knowledge pertinent to their work group and organisation.
- mechanisms enabling end-users to publish and share their enriched work products with others.
- user interface agents (Lieberman 1997) that point out potential problems or missed opportunities in work products, point out possible links and dependencies to the work of other individuals or groups in the organisation, and inform user activities by providing relevant cases stored in the memory.

In this project, we will use D3E and WebOnto as starting points. D3E provides a document-centred virtual discussion space and a toolkit supporting cost-effective web-based publishing. WebOnto supports the collaborative construction of knowledge models (based on OCML) over the web. Together, D3E and WebOnto support domain construction and perspective-taking. We will also add learning-on-demand agents to provide more active support for reflection-in-action.

Cedar will support two kinds of developers – knowledge engineers and information providers. It is envisioned that knowledge engineers will use CEDAR to create initial knowledge base 'seeds' by re-using and refining existing model libraries. However, the key contribution of the CEDAR approach is to enable small teams of information providers to efficiently publish web-based documents linked to integrated discussion spaces and knowledge models without requiring extensive specialised technical knowledge. We expect the CEDAR toolkit to prove cost effective in two ways. Firstly, the toolkit will make it possible for information providers, such as corporate trainers from BAe's Virtual University, to construct organisational memories with only minimal assistance from knowledge engineers. Secondly, the toolkit will automate large parts of the publishing process which reduces both the time to create a site and the time required to verify a site's correctness. Experiences with D3E indicate that time savings of two orders of magnitude (from weeks to hours) are achievable (Sumner and Buckingham Shum 1998).

In this project, the user partners will serve as both CEDAR developers and CEDAR users. BAe Virtual University personnel will use the CEDAR toolkit to develop The Team Workbook to assist 'shop floor' workers at BAe in learning and applying planning methodologies. TecInno will act as CEDAR developers, using the toolkit to create an Experience Archive to help their customers at JOLA engage in better product planning. DFKI will use the CEDAR toolkit to develop The ProGroup Electronic Manual for their users at Saarbergwerke AG, assisting technicians distributed across a global workforce to diagnose complex machine problems and disseminate specialised technical expertise.

2.4.2. Technical Objectives of Proposal

A key technical deliverable of this project will be the CEDAR toolkit. The toolkit will enable small teams to quickly construct task-specific organisational memories for various workplace settings. Our technical work in the project will centre on integrating our existing tools at two levels: the interface (user's view) and the toolkit (developers' view). We will adopt an iterative and participatory (Greenbaum and Kyung 1991) development strategy where design and implementation activities are driven by use experiences in our three case studies (described in Project Strategy Section). This strategy will be used to produce the CEDAR components:

Component A: Client tools based on standard web browsers enabling users to view, publish, and enrich documents and to extend knowledge models during use.

D3E and WebOnto will be integrated at the user interface level, integrating a knowledge view or concept map with the document and discussion space views. We will be able to produce a robust and useful system quickly since both of these tools are very mature, having been evaluated and used extensively. This integration will support domain construction and perspective-taking processes. As part of this proposal, we will also extend these tools to enable non-technical users to enrich their work products by linking to parts of the knowledge model and to enrich the knowledge models themselves by providing facilities for discussing, annotating, and refining aspects of the models.

Component B: Client tools supporting developers to create and manage the document archive.

D3E and WebOnto will be integrated at the toolkit level. State-of-the-art text analysis techniques as provided by the Specialist Board will be employed for (semi) automatically classifying natural language documents and attaching documents to formal categories of explicit knowledge models.

Component C: CEDAR memory server plus three memory 'seeds'.

We will develop a contextually-enriched document server and tools for managing the server. Part of the server infrastructure will include logging tools to support assessment activities such as analysing use patterns and memory growth. In addition, the OU will assist the industrial partners to create an initial 'seeded' memory server for each of the three cases. Relevant work products and corporate documents will be collected and published on organisational intranets using the CEDAR toolkit.

Component D: Learning-on-demand agents.

We will modify and extend the case-based client-server system to: (1) operate with the CEDAR document structure and architecture and (2) support operational areas important to the industrial partners such as methodology training and product planning. The integration of both push and pull agents into CEDAR will help support reflection-in-action. This may require more sophisticated case representations and similarity measures, as provided by CBR Works or as implemented in the Electronic Fault Recording system.

2.4.3. Methodological Objectives of Proposal

A key issue in organisational memory research is sustainability: it is relatively easy to create a memory but it is more difficult to successfully integrate it into work practices to ensure use and growth. In this area, social issues are as important as technical issues. Successful efforts in creating sustainable memories recognise that using and contributing to the memory must be harmonised with both work practices and organisational practices (Terveen, Selfridge et al. 1993). Surveys of our own experiences and the experiences of others highlight three lessons:

Lesson 1. A comprehensive memory lifecycle is needed to guide deployment, use, and maintenance. One lifecycle we will build on is the seeding, evolutionary growth, and reseeding model (Fischer, McCall et al. 1994). According to this model, knowledge engineers work with end-users to create an initial memory 'seed.' End-users extend the seed during use, contributing to evolutionary growth. At times after periods of extensive growth, knowledge engineers return to restructure and re-organise the memory, an activity called 're-seeding.'

Lesson 2. In recent times, there has been a realisation that there are no simple categories describing people's skills such as end-users *versus* developers. Rather a broad spectrum exists of people with varied skills and motivations with respect to technology. In many cases, effective and sustained use of technology has been accompanied by the emergence, and organisational acknowledgement of, a middle ground of technically sophisticated end-users, referred to as local developers (Gantt and Nardi 1992) or collection managers (Rein, McCue et al. 1997). These people assume responsibility for maintaining and modifying the system to support changing work practices and organisational needs. A benefit of local developers is that they are part of the work community and have a deep understanding of existing work practices and needs.

Lesson 3. It is insufficient to disseminate technology by simply 'throwing it over the wall' and assume that it will revolutionise work practices (Orlikowski 1992). Studies have found that a proactive approach is needed to help practitioners foster the new 'frames of reference' necessary for understanding the possibilities and appropriate uses of the new technologies (Orlikowski and Gash 1994).

Building on these ideas, we will adopt an initial methodology based on participatory evolutionary development (PED) (Sumner and Stolze 1997). In the PED model, individuals in the workplace, with participatory design and tool adaptation skills, help practitioners in co-evolving their tools and practices in appropriate ways. According to PED, the following roles and lifecycle processes should be supported:

Seeding. Knowledge engineers and information providers (such as corporate trainers) will work with local developers to create an initial archive seed using the CEDAR toolkit.

Continuous Growth and Maintenance. Using CEDAR clients, practitioners (end-users) and local developers will contribute towards the growth of the archive through use. Local developers will assist practitioners in making more extensive changes to the archive structure and knowledge models, and will take responsibility for document collection management.

This initial methodology will be refined based on use experiences in each of the three cases. The methodology deliverables for this project will include:

- A lifecycle process model spanning tool support and participant role recommendations.
- Role articulation for various participants (e.g., practitioners, local developers, information providers, and knowledge engineers) describing their major activities and prerequisite knowledge and skills.

- Requirements for a training approach to foster the necessary new frames of reference based on our process model and role articulation. This will feed into our ENRICH consulting pack development.

2.5. Project Strategy

We will pay special attention to the process of integrating CEDAR tools into work practices. Rather than separating phases of development followed by deployment of pilot applications, the process of methodology and tool development will be intertwined with deployment from the very beginning. Early deployment will provide important feedback and will drive their further development. Specifically, we will use a case approach: three pilot projects will provide the context for all implementation and evaluation activities. Each case involves both types of CEDAR users – developers and end-users – but in different domains and business contexts (Table 4).

Table 4. Overview of the three pilot projects.

Project	Description	Developer Site	End-user Site	Business Domain
Team Workbook	Promoting best practices through the intertwined teaching and use of planning methodologies such as TQM	BAe Virtual University	BAe 'shop floor' end-users (large company)	Aerospace
Experience Archive	Assisting the sales force and engineers to share expertise through enriched product documentation archives	TecInno	JOLA sales force and engineers (SME company)	Engineering Design
ProGroup Electronic Manual	Supporting wide area organisational learning using a proactive electronic group manual to integrate multiple group memories	DFKI	Saarbergwerke AG machine operators and power engineers (large company)	Power Industry Waste Management Mining

To meet our technical and methodological objectives, we will engage in the following activities:

Work Package 1: Management. To ensure quality across the project and promote comparisons across the cases, a Steering Committee will meet quarterly, consisting of key personnel from each partner and a small group of industrial leaders. We will also apply the ENRICH approach to our own project documentation and communication practices. We will begin by using D3E to publish and discuss our project documentation and intermediate results over the Web. We will use an existing secure D3E server already available at the OU. We will switch to CEDAR as it becomes available.

Work Package 2: CEDAR Prototype Development. We will integrate D3E and WebOnto at the user level to create the CEDAR client interface. Using the D3E and WebOnto toolkits separately, as they currently exist, developer sites will generate targeted archive prototypes based on the integrated interface design to support small scale trials in each of the three cases. Supplier partners, developer sites, and end-user sites will collaborate to construct archive prototypes for each case, which will consist of a task-specific set of hypermedia documents linked to a supporting knowledge model. The particular 'tasks' chosen will reflect the envisioned uses during the first trials.

Work Package 3: CEDAR Prototype Trials. The CEDAR interface and the archive prototypes will be evaluated through small scale trials in each of the three cases. We will compare results and experiences across the three cases. Results will be compared at two levels: (1) experiences of end-users using the trial system and (2) experiences of developers creating the initial system. These results will be used to refine our methodology, particularly in the areas of role articulation and training element development.

Work Package 4: CEDAR Toolkit Development. Based on the evaluations of the first trials, we will refine the client interface and the initial structure of the archive prototypes. The improved client interface and archive structures will directly feed into our next technical objective – the integration of D3E and WebOnto at the developer levels to produce the CEDAR toolkit. Here, we will integrate specialist technologies from TecInno and DFKI into the OU baseline tools, including enhancements to the CEDAR architecture, integrating CBR into the CEDAR memory server, and adding push (learning-on-demand agents) and pull (information retrieval) mechanisms.

Work Package 5: CEDAR Toolkit Trials. The refined methodology (work package 3) and initial CEDAR toolkit (work package 4) will be used by developers sites to produce memory 'seeds' suitable for larger scale deployment. The resulting CEDAR systems will be evaluated with larger user groups at each of the case sites. Evaluations of these trials will focus on: (1) assessing our improvements to the Client interface, (2) assessing the impact of the agents on work practices and learning, (3) assessing the usability of the

CEDAR toolkit by information providers, (4) assessing our developer seeding methodology, and (5) assessing the cost effectiveness of the CEDAR toolkit.

Work Package 6: Dissemination and Exploitation. The results from the second trial will feed into our dissemination and exploitation activities. At the methodological level, these results will be used to refine all elements of our methodology – the process model, the role articulation and training elements. At the technical level, experiences from the second round of trials will feed into further development plans for each of our four software deliverables: the CEDAR toolkit itself, The Team Workbook, The Experience Archive, and the ProGroup Manual.

All partners will be deeply involved in the trial analyses and cross-case comparisons. It is through these comparative activities that our methodology will be refined and enhanced. Our case approach enables user partners to immediately profit from the ENRICH approach by constructing a memory system based on their immediate business needs (BAe) or the needs of a customer (DFKI and TecInno). We'll now describe each case, particularly the problem being addressed, the end-users, and the expected outcomes.

2.5.1.BAe Case: The Team Workbook

British Aerospace has in place a change programme called 'BenchmarkBAe' designed to help the Company achieve its goal to become a benchmark company through the pursuit of excellence. This change process is being led by the CEO and the senior management team, who have identified five values – Customers, People, Performance, Innovation & Technology, and Partners – as keys to achieving this goal. Value Teams comprising members from the senior management team have established and defined practices and behaviours that drive and sustain the Company Values (published in 'Our Value Plan' issue 2 1998). This work is being consolidated into a series of educational programmes that will eventually embrace all employees. As part of this larger programme, a Team Workbook has been developed to help promote the understanding and application of these values in the operational and business environment.

The Team Workbook is a planning tool designed to stimulate more effective working of both team leaders and their teams. The Workbook is based around a three step process: (1) preparing the values-based plan, (2) declaring and delivering the plan, (3) reviewing and improving the plan and work practices. These iterative steps provide a learning framework enabling teams to secure continuous improvements in their sphere of responsibility. The current Workbook is paper based and is in the process of being deployed across the entire company (44,000 employees). Using the Workbook, local teams identify their internal customers and suppliers, map their key processes, measure their performance, and collectively work to secure higher levels of performance and greater customer satisfaction. The Workbook includes Total Quality Management (TQM) tools and is designed to be suitable for teams with little or no prior TQM experience. A support structure of trained facilitators within an overall change management framework is also being implemented.

During this project we will construct a digital Value-Enhanced Team Workbook underpinned by a corporate knowledge base representing the five values. The Value-Enhanced Team Workbook will support teams to articulate their plans directly within the Workbook and to discuss and review their plans on-line. It will enable teams (e.g., customers and suppliers) to share experiences and best practices by linking shared plans and values. It will also enable teams to feed into and augment the corporate knowledge base.

The Team Workbook is an ideal testbed for this project for several reasons. First, it provides a natural fit between business needs and our technical and methodological approach. While the paper-based workbook helps teams to become communities of practice, it does not directly contribute to organisational learning because the results of the planning activities are not captured, re-used or shared. Second, in parallel with the deployment of the Workbook, British Aerospace has established an internal browser-based intranet enabling us to use the intranet coupled with knowledge modelling tools to deliver the Workbook concept. Finally, we will leverage the support structure of the trained facilitators to test our proposed methodology.

In the Team Workbook case, we will:

- Formulate an initial ontology containing two interrelated layers. One layer will represent the corporate values and the other layer will represent key processes from the Workbook.
- Use CEDAR to construct the Value-Enhanced Team Workbook with embedded discourse facilities and underlying knowledge models.
- Integrate push (learning-on-demand) and pull (case-based retrieval) agents supporting the appropriate use of Workbook methodologies and the identification and delivery of related plans.
- Deploy the Value-Enhanced Workbook in two trials. The first trial will consist of one 'shop floor' site in BAe experienced with using the paper-based Workbook. This site will use the Enhanced Workbook prototype to construct an initial plan. The second trial will involve two 'shop floor' sites in BAe.

- Test and refine the CEDAR methodology, particularly in the areas of role articulation and training element requirements. This case will enable us to test our information provider and local developer roles in particular. Information providers (from BAe's Virtual University, the Workbook authors) will use CEDAR to construct the Value-Enhanced Workbook. We will examine how trained facilitators could play the role of local developers.

Expected Outcomes. In this case, we will focus on examining the usefulness and usability of the Value-Enhanced Team Workbook, and the relative contribution of linking groups via the underlying corporate knowledge model, according to the following working hypotheses:

Individual learning and reflection will be supported by providing practitioners with active support for constructing and reviewing plans using TQM methodologies. We will consider reflection to have occurred if individuals discuss through the workbook their plans or the methodologies. We will consider learning to have occurred if individuals change their plans based on agent intervention.

Group learning and domain construction will be supported by linking the plans to the underlying knowledge bases and enabling practitioners to enrich both their own plans and the knowledge base. We will consider domain construction to have occurred if practitioners enrich their own plans with links to the knowledge bases and if practitioners extend or discuss the underlying knowledge bases.

Organisational learning and perspective-taking will be supported by linking groups using the underlying corporate values model. We will consider perspective-taking to have occurred if practitioners engage in debate or negotiation about another team's plan with respect to their own planning objectives.

2.5.2 TecInno/JOLA Case: The Experience Archive

JOLA is a SME with 67 employees, that produces electro-mechanical and electronic devices. The company is a supplier of exception-detecting equipment. It has a diverse portfolio of products (e.g. level controls and leakage detectors) and operates in a complex market. JOLA is active in all countries of the EU, in many countries of Eastern Europe and in Israel, Korea and Malaysia. It has subsidiaries in France and in the United Kingdom and co-operates with distributors in other EU countries. Employees from the subsidiaries and sales distributors work together at the headquarters in Lambrecht, Rhineland-Palatinate and form a multicultural and multilingual team.

The customers of JOLA are mostly other SMEs from the area of construction and building as well as engineering. In its specific markets JOLA has to act very flexibly to meet diverse customer demands. The orders come in spontaneously and are often urgent due to the nature of the product line, e.g. leakage detectors, which often have to be installed in a very late stage of a construction project due to neglect during the planning phase. Sales people as well as engineers need access to numerous technical documents and best practices to be able to solve a customer's problem quickly. Since JOLA has a small sales force with particular areas of expertise distributed over Europe, it needs efficient means to share knowledge and to train the sales force on the job. CEDAR in conjunction with an intranet offers the opportunity to meet this need.

In contrast to BAe, JOLA is a SME with very different organisational structures and resources. Consequently, we expect to learn different lessons than in the BAe case. The contribution of the JOLA case is to deliver a showcase of how to implement ENRICH technology in a SME environment. The BAe Team Workbook case, on the other hand, is of particular importance for the dissemination and the uptake of the results with end-users in a large corporate environment.

In the JOLA case, we will:

- Formulate an initial knowledge model (concept map) on the utilisation of JOLA products to allow for the capture and structuring of product know-how.
- Apply CEDAR to the technical product documentation to enrich its representation in order to enable further development and discussion.
- Integrate the approach into the organisation during the trial phases, to test possible new ways of collaboration and learning for the sales force and the engineering department.

Expected Outcomes. The enrichment of technical documents and the introduction of explicit knowledge models will enable JOLA engineers and sales people to share their expertise. Learning will take place when a sales person solves a new customer problem by applying JOLA products. This requires individual learning to tackle the new situation based on reflection on known problem solutions supported by case-based retrieval. The documented new product application will be shared among the sales people as well as with engineers to allow for group learning and the furtherance of domain construction. Such learning will in particular encourage the product improvement process at JOLA based on the discourse between sales and engineering. Organisational learning in this context is a long term perspective involving the strategic targeting of the product portfolio, and

thus will be difficult to prove within the short term of the envisaged project. However, we will consider the important first step of perspective-taking across work communities to have occurred if sales people and engineers discuss and debate their respective viewpoints using the Experience Archive.

2.5.3 DFKI/Saarbergwerke Case: The ProGroup Electronic Manual

Saarbergwerke AG is an international energy and technology company with over 18,000 employees and annual sales of more than DM 4 billion. The corporate group is in the midst of change. Within the past few decades, its two main areas of operation, mining and power generation, have become the source of numerous new activities in the fields of energy, environment, trade and services, and rubber. Its range of services covers everything from providing foreign coal mines with state-of-the art technology, exporting innovative power station know-how, constructing regional long-distance heating networks, to working on combined solutions regarding waste disposal and environmental protection. This highly innovative environment continuously challenges the company's ability to build up, evaluate, and disseminate knowledge in crucial technical areas.

In previous projects with DFKI GmbH, Saarbergwerke AG developed and deployed a system supporting the systematic recording, structuring, and dissemination of knowledge and experiences relevant to the maintenance of complex mining machines. During machine operation, events, observations, and actions are documented and classified into ontological structures describing the machine configuration, diagnostic process, and observation/fault identifiers. These structures ease access to large archives of relevant technical documentation.

The systematic revision of knowledge entries supports the continuous evolution of the accumulated knowledge. Model-oriented, heuristic retrieval mechanisms realise a goal-oriented knowledge dissemination as an effective communication support. *The results clearly demonstrated the high possible benefit which can be gained from IT support for organisational learning.* In the face of the growing importance of global technology dissemination as a central business area for Saarbergwerke AG, the extension of this approach towards an encompassing memory for a global community of practice is an important business objective. The global community of practice emerges from the integration of various local task forces which are empowered to share their particular experiences.

In the ProGroup case, we will:

- Integrate multiple group memories at various locations into a common discourse environment, using web-based techniques provided by the CEDAR toolkit. This satisfies a key technical prerequisite for wide area organisational learning.
- Develop and realise a methodology for the collaborative creation of ontological structures shared between the local groups. This will be done with the CEDAR toolkit and the ENRICH methodology.
- Extend and complement the model-based pull mechanism of the recently deployed electronic fault recording system (ESB) by an active, context-sensitive push mechanism based on the retrieval machinery of the CEDAR case retrieval components.
- Develope push/pull learning-on-demand agents utilizing the CEDAR text analysis components. These agents will analyze the accumulated experience database in order to automatically generate: suggestions for classifying experience logs and technical documentation, suggestions for new domain concepts, and explanations of faulty machine behaviour.
- Apply and test the approach by deploying the results in several coal mines equipped by Saarberg technology and continuously evaluating their use.

Expected outcomes. The results of the ProGroup study will extend the profitable use of recorded maintenance experience from a local to an organisation-wide, global scale. More specifically:

Individual learning and reflection is supported by the active presentation of relevant experiences, based on the experiences' organisation and structuring by explicit knowledge models. The presented information will immediately influence the ongoing diagnosis and repair process which in turn leads to immediate comments and extensions of the knowledge base. Technical documentation, as an, up to now, virtually not used knowledge resource, will be considerably better exploited.

Group learning and domain construction is supported by the extension of the explicit knowledge models on an as-needed basis as required for classifying completely new maintenance experiences. This domain model extension is done in cooperation between the machine operator on duty and the supervisor who maintains the knowledge-base off-line. Moreover, integration of the knowledge models of several groups (and of their experience databases as well) leverages and multiplies the usefulness of single experiences and stimulates discussions about different knowledge structures constructed by different groups.

Organisational learning and perspective-taking can be supported if knowledge structures (with respect to fault categories, critical operations, and standard repair procedures) emerging from the maintenance activities are

discussed between people from engineering, planning, and training departments, thus influencing the construction of new machines, the planning of mining logistics, and the training of machine operators.

As in the BAe case, the ProGroup study shares the overall goal of continuously improving ongoing work processes and quality management. As in the JOLA case, improved exploitation of technical documentation plays a crucial role. Thus we expect valuable synergy among the three case studies. Additionally, the fine-grained technical knowledge structures and the focus on geographically distributed cooperation are distinguishing characteristics of the ProGroup pilot.

2.6. Evaluation

The Open University will coordinate evaluation activities across the three case sites to ensure a consistent assessment framework, and coherent data collection and analyses. Consistent with recommended case study approaches, we will collect several types of qualitative data in order to attain convergence (see Table 5) in our final analysis (Yin 1984).

Table 5. Evaluation techniques for assessing support for integrated learning processes and business objectives.

Business Objectives	Learning Process	Observable Activities	Evaluation Technique
Supporting individuals and groups to continually reflect on and improve their work practices.	Reflection-in-action Domain Construction	Additions to the discussion area or the knowledge models Changes to work products as a result of agent activity	Server Log Analysis Workplace Observations
Supporting distributed groups to share 'best practices' and improve their coordination efforts.	Reflection-in-action Perspective-taking	Discussion and reuse of other people's work products or knowledge models. Discussion resulting from agent activity	Server Log Analysis Memory Content Analysis Workplace Observations Surveys
Identifying core competencies and nurturing their further development by bringing people together (across time and geography) with relevant expertise.	Domain Construction Perspective-taking	Additions to the discussion area or the knowledge models. Discussion and reuse of other people's work products or knowledge models. Linking of separate models or the construction of a new shared knowledge model.	Server Log Analysis Memory Content Analysis Workplace Observations Surveys

Evaluation methods that will help assess the ENRICH approach include:

Server Log Analysis. The CEDAR memory server will maintain logs tracking usage patterns and changes to the contents and structure of the memory. This analysis method is useful for looking at longitudinal patterns and for looking at the actions of geographically distributed communities.

Organisational Memory Content Analysis. This involves looking at specific cases or products stored in the memory, specific parts of the knowledge model, and discussion analysis. These focused examinations complement the broader-brush log analyses by providing finer-grained accounts.

Workplace Observations. We will also conduct workplace observations at each case sites. The purpose of these observations are to gain an understanding of the tools in use and the impact of the tools work and organisational practices. These observations will be particularly helpful for refining our methodology.

Surveys. In cases involving geographically distributed users, we will use survey techniques rather than workplace observations.

Metrics. Metrics will be collected in order to estimate the time, cost, and effort of constructing a memory seed using CEDAR. These metrics will help to assess the toolkit's cost effectiveness.

2.7. Summary of ENRICH Deliverables and Contributions

To summarise, the ENRICH project will result in five deliverables which can be readily exploited:

- The CEDAR Toolkit
- The CEDAR Methodology (through our consulting packs)
- The Team Workbook
- The Experience Archive
- The ProGroup Electronic Manual

The ENRICH project is innovative with respect to its technological basis, its integrated learning approach, and our case-oriented project strategy. We envision making important contributions in several areas:

– Our integrated learning approach is soundly based on theories of working and learning and on extensive empirical evidence.

– CEDAR will serve as a "total system" showcase since it is designed to support our integrated learning approach. Additionally, its theoretically and empirically motivated features will be refined through use by real end-users to ensure that it is both useful and usable.

– The CEDAR Toolkit will demonstrate cost effectiveness and practicality. A unique contribution will be our focus on making sophisticated technologies accessible to relatively non-technical information providers and cost-conscious SMEs.

– Three pilot projects in a wide spectrum of application domains (aerospace, engineering design, power industry) will serve to refine and assess the ENRICH approach in naturalistic settings. Each project will result in a readily exploitable application in its particular business domain, By comparing across the pilots and generalising from our common experiences, we will be in a better position to develop tools and methodologiess with broad applicability across numerous business domains.

This work builds on a solid foundation of EU-funded research among partners with strong track records. Successful deployment is ensured by involving both end-user and developer sites from diverse business sectors and organisational contexts from the very beginning. This undertaking is only possible through the combined, complementary expertise of all consortia members.

3. EUROPEAN DIMENSIONS

This project will develop advanced organizational learning tools and methodologies and apply them in the context of European industry. European dimensions of the ENRICH project provide the following added values:

- Technical - to implement ENRICH requires state-of-the-art technology in learning environments, Internet technologies, knowledge modelling, CBR, and expertise in evaluating such systems. Such a mixture of expertise is only available at the European level.
- Cultural - Although the organisational, social work and learning cultures vary from country to country, the involvement of users from three different European countries ensures the required generality of ENRICH results. Support for collaboration across geographic boundaries at the group and organisational levels facilitates integration of work forces from different countries.
- Economic - Life-long learning is increasing in importance in the context of global competition. Reacting quickly to customer needs is key to success in the global marketplace. Tools which foster such skills are strongly required all over Europe and in particular to support the European SME industry (such as our user site at JOLA).
- Dissemination-related - We expect the results of ENRICH to have immediate impact on a large community of subsidiaries, distribution and development partners of our industrial partners which include Belgium, France, The Netherlands, Ireland, Turkey, Czech Republic, Poland, Bulgaria, Switzerland.
- Scientific - the project builds on scientific results that have been obtained at a European level.

3.1. Partners' European Links

The following European links can be used for dissemination of ENRICH results:

The Open University currently has 20000 students studying outside the UK in countries of Western and Central Europe, and the OU Business School is the largest supplier of business degrees and certificates in Europe. As part of our exploitation plan, we will feed the results of ENRICH into a new knowledge management course within our MBA profile.

DFKI has extensive links with German industry and maintains close working contacts with knowledge management companies in Switzerland and The Netherlands.

British Aerospace plc has strong European links through its partnership in the European Defence Industry as seen in programmes such as Tornado, Eurofighter and Airbus, and its future perspective is firmly European to counteract American competition.

TecInno GmbH has organised a "Virtual Company" for work on complex customers' projects which cannot be solved by a single company. TecInno partners are in Germany, France, Switzerland, and Ireland. These partners will have access to ENRICH results.

Technical University of Kosice has links with partners in the Czech Republic, Hungary, and Romania who will have access to ENRICH results.

The project partnership complies with the rules as defined in Section 2.1 of the call and the European dimension is enhanced by participation of an academic partner from an EU associated country - the Slovak Republic. This partnership results from a previous successful co-operation with OU/KMI within the INCO Copernicus project ENCODE.

3.2. European Projects We Build On

VITAL: A methodology-based workbench for knowledge based systems life-cycle support, (Esprit II, project P5365), 1991 - 1995, http://kmi.open.ac.uk/~john/vital/vital.html

ENCODE: Environment for configuration design, (Copernicus, project 940149), 1995 - 1998, http://kmi.open.ac.uk/~zdenek/copern.html

HCReMa Health Care Resource Management Project HC 3103, Telematics Applications Programme, http://www.vision.auc.dk/CHI/projects/HC-REMA/HCREMA.html

COMPULOG: DFKI hosts the ESPRIT network of excellence in computational logic; http://www.compulog.org.

INRECA (Esprit III Project Nr. 6322), An Integrated Platform for Reasoning from Cases, 1992-1995

4. INDUSTRIAL RELEVANCE

> "Information workers have grown from less than 10% of the work force at the turn of the century to more than 70% today..."

[from Strategic Requirements Board report set by DG XIII/C in preparation for the Community 5th Framework Programme (1998-2992)]

We are at the beginning of the Knowledge Society. To act in this society requires sophisticated support such as intelligent knowledge management, learning on demand and the encouragement of innovation. To be able to compete in the global marketplace, enterprises need to embrace continuous learning and qualification processes. The integration of learning on demand into daily work practices is a strict requirement. This can only be gained by the delivery of context related knowledge, where the context is a derived from the current task, domain and user. The usability of such a system depends on how quickly a user can focus on relevant information.

Our proposed tools and the integration are key to delivering a system which fits into the above scenario, since ENRICH will provide:

- organisationally integrated learning on demand,
- contextually enriched information and knowledge representations,
- context specific support for information access, and
- shared access to relevant information and knowledge 24-hours per day.

Indeed, ENRICH will provide the tools that are required to bring the *Learning Organisation* to life. Thus ENRICH goes far beyond potentially competing systems, which are basically products from the areas of document management systems, which lack the incorporation of knowledge, and corporate memory systems which contain graveyards full of unusable information.

4.1. From 'Lean' Document Servers to Knowledge-Enriched Intranets

Web technology and applications are growing at a rate unprecedented for computer-based information technology. The amount of Web sales is expected to increase from $2.6 billion in 1996 to $220 billion by 2002 (International Data Corporation). Corporate intranets are expected to be the fastest growing component of that market. Netscape™ reported 1996 revenue representing a 400% increase on revenue for 1995. The company attributed this growth to their intranet products (*The Wall Street Journal* 23rd October, 1996).

Unfortunately, despite the dramatic increase in sales, the lack of maturity of Web technology has prevented even more widespread use. Of 76 information technology executives surveyed, 37.5% said that technology immaturity was the major factor preventing the use of the Web in their companies (PC Week 7th October 1996). This immaturity is particularly striking when using Web technology to support work processes. As reported by Xerox ™, which has more than 200 Web servers supporting 20, 000 employees:

> "this internal Web, as an environment for supporting organisational work, is falling short of our expectations and hopes in significant ways"

[Rein, McCue and Slein, 1997]

Some of the problems at Xerox were caused by the separation of work products and context, and the off-the-shelf tools lack of support for local developer roles. ENRICH addresses this problem by delivering: (1) a set of tools which tightly integrate work products with related discussions and informal and formal representations of shared understanding, and (2) a methodology showing how to effectively situate the technology within the workplace to achieve continuous improvements. In effect, companies will be able to create cost-effective and sustainable *Knowledge-Enriched Intranets*.

The CEDAR toolkit will enable developers to efficiently create environments tailored to a client's task specific needs. Software reuse is promoted through the layering capability of our knowledge modelling language, and distribution and maintenance are facilitated by our Web server and Java client architecture.

4.2. Market Opportunities for Knowledge-Enriched Intranets

We see ENRICH positioned within the Web Technology sector, which is predicted to be a market worth $220 billion, with minor overlaps with document management and corporate memories. Current document management systems are only useful when deployed to support relatively simple, well-understood work practices involving factual information which does not involve interpretation. Corporate memories suffer from "one size fits all" and lack of sustainability problems. The predicted rapid growth of the Web indicates that the potential impact of the project is considerable. We are convinced that the proposed case studies will not only instil an awareness of the benefits of the ENRICH approach within our target industrial sectors but also form the initial ENRICH market.

As an example of the industrial impact our customised environments will have, we shall describe the impact of ENRICH within British Aerospace. British Aerospace's businesses are focused on the defence and commercial aerospace sectors and it markets a wide product range throughout 72 different Countries. The aerospace industry is still recovering from the global recession of the early 1990's. During the last few years the Company has responded strongly to changes in the markets to achieve its current level of shareholder value. The Company however can not afford to be complacent about its position, since the growing recovery in the markets will mean growing competition. The enormous changes in the global markets will bring both threats and opportunities and the company needs to capitalise on the new global situation and gain a competitive advantage.

Because the global challenges apply throughout British Aerospace plc, a corporate wide strategy is required to meet them. The Company's strategy is focused on its five values: people, performance, customers, partnerships and innovation and technology. The Team Workbook, originally designed to increase team performance, will now have explicit links to the five values through a Values based knowledge base. In addition to exploiting the investment being made in the Corporate Intranet, the use of the on-line Workbook will result in a dramatic shift in the amount of effective learning which occurs in British Aerospace thereby increasing its competitiveness and sustainability. For these reasons British Aerospace is deeply committed to applying and developing the ENRICH framework and supporting technologies to ultimately create a *Corporate Values Based Intranet.*

4.3. Impact on Society

As stated earlier, individuals and organisations will require sophisticated support to work in and contribute to the social fabric of the Knowledge Society. We envisage that ENRICH will provide a portion of the required scaffolding. At the core of our methodology, individual workers are encouraged to continually reflect on their work practises and are empowered since they can contribute in a meaningful way to the improvement of work practises. By adding to the organisational memory, workers feel that they have a direct impact on the company's competitiveness and on the work of their colleagues. At the social level, we sincerely believe we now have a unique opportunity to use the convergence of telecommunications and computing technologies to create enhanced intranets promoting a European model of society.

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