European E-Learning: Important Research Issues and Application Scenarios

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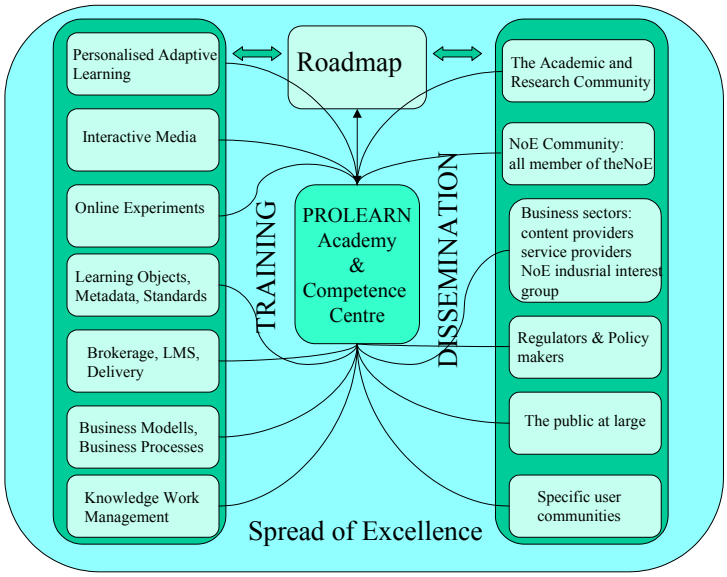
While E-Learning is increasingly influencing university and workplace education in Europe, several critical issues still have to be solved in order to achieve the full potential of technology enhanced learning in many of these learning scenarios. The EU/IST FP6 PROLEARN Network of Excellence in Technology Enhanced Learning is focussing on these issues, and advancing the state of the art in this area, through a large concerted effort of more than 120 research institutions and companies working together in the PROLEARN Consortium and as PROLEARN Associated Partners. Key issues involve advanced production, deployment and exchange of professional learning resources and the use of these learning resources for professional training in SME's and larger companies. Key areas involve the use of personalized learning and interactive media resources, with learning resources connected to real-world settings and reusable in different contexts. Further PROLEARN key areas cover the use of brokerage platforms and services, appropriate business models and networks for specific markets, and advanced workplace arrangements integrating E-Learning and knowledge work management both in smaller and larger European companies.

Restructuring and Integrating European Research on E-Learning

In the United States, enterprises invest 20 percent of their budget (13 Billion US-$ out of 66 Billion US-$) for professional education in E-Learning activities (Corporate University Exchange 2000, http://www.corpu.com/). A similar trend is now becoming apparent for Europe as well. According to research by the Gartner Group, the European market of corporate E-Learning had a capacity of 829 million $ in 2001, and it will grow to 7.4 billion $ by the year 2004 (Scienter, Bologna 2001). Despite these impressive figures, it has repeatedly been reported that the actual impact of R&D on learning technologies remains limited so far, indicating that too few R&D results are picked up in actual practice. One of the reasons for this is that technology enhanced learning research and researchers are scattered across quite a few distinct communities, with often very limited awareness of the other communities. Different communities focus on media production, digital libraries, the Semantic Web, personalization and adaptation to the individual user, brokerage services, computer-supported collaborative learning, business models, social engineering and other areas. It is the goal of the PROLEARN Network of Excellence to substantially increase the cooperation between these communities and to integrate the various research communities as well as E-Learning providers and companies through joint research, grand challenge workshops, best practice forums and initiatives for enhancing the quality of E-learning in crucial application areas. Summer schools will enable young researchers and professionals to advance their knowledge on the state of the art in technology enhanced learning, and professional networking and joint research in the context of the PROLEARN Academy. The PROLEARN Virtual Competence Center will integrate consulting, dissemination and networking initiatives between research and company partners, and tightly couple advanced research and application scenarios for technology enhanced learning in the PROLEARN context.

The PROLEARN Academy is designed to integrate and co-ordinate long term research amongst the network partners and beyond. Training is an important component of the academy and will disseminate technology enhanced learning state of the art and best practice across Europe. Just as the network itself is open for new partnerships, so are the services that are offered by PROLEARN. Activities include regular PROLEARN meetings, publications, symposia, etc. that are clearly targeted at the global R&D community in this field. The PROLEARN Virtual Competence Centre focuses on networking research institutes and European industry and on the active participation of corporate users in the actual R&D work. Specific consulting services will be offered to companies, from special training courses (train the trainers) to assistance with the implementation of E-Learning strategies in an organization. Both PROLEARN Academy and PROLEARN VCC are strongly supported by, and interrelated with, dissemination and training.

Academy and Competence Centre in the PROLEARN Context



Contributions to standards

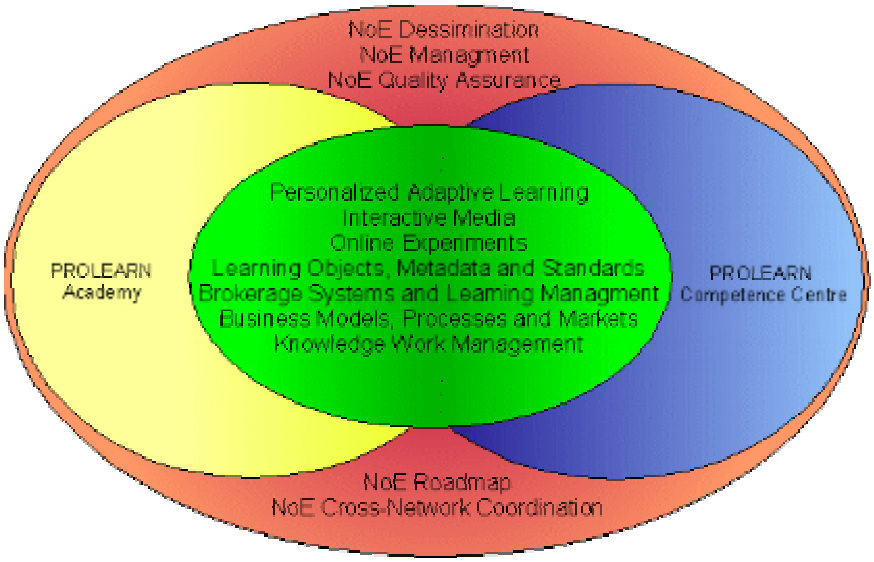
Standardization is an important and critical success factor for technology enhanced learning research and application, as it enables technical and semantic interoperability between E-Learning content and infrastructures. Formal standardization is currently taking place in the context of the IEEE Learning Technology Standards Committee (LTSC), the Centre Européen de Normalisation (CEN)/Information Society Standardization System (ISSS) *Learning Technologies WorkShop (LTWS),* and the the ISO/IEC JTC1 Subcommittee 36 on "Information Technology for Learning, Education, and Training". These accredited standards organisations receive specifications from consortia, projects, foundations, and all kind of initiatives (ADL/SCORM, AICC, ALIC, ARIADNE, IMS, EUN …). In a first phase, this is very much a *bottom up* process: specifications are developed and experimented with by consortia, who submit their work for further consensus building to the accredited standardization organisations (of which there are exactly three that are relevant to learning). After the upward process, the flow often reverses, as consortia start developing so-called *application profiles*: these are specifications that are fully compatible with the standard, but adapt it to the needs and requirements of a particular community. In the case of LOM, for example, the ARIADNE foundation has developed such a profile for its multilingual community. In this process, some data elements in the overall LOM scheme have been made mandatory, some value spaces have been restricted and some interrelationships have been imposed. This enables the ARIADNE Foundation to develop more powerful tools for its community.

European research is increasingly influence the standardization process in technology enhanced learning. Building on and improving already existing standards like LOM, SCORM, LIP, IMS Learning Design and other relevant standards will further extend their applicability and outreach and speed up the process of their adoption.

Research Issues for E-Learning

Joint European research activities in PROLEARN currently focus on seven key areas identified as crucial for technology enhanced professional learning. In order to make E-Learning successful and applicable in a variety of application scenarios, we have to integrate extensive interactive experiences, including the usage of interactive media and videoconferences, simulations and hands-on experiences in the context of online and virtual laboratories. Great potential for advanced E-Learning environments have techniques to personalize learner experiences based on user and group profiles, taking the actual needs of specific learners into account. Brokerage systems can significantly help to share and exchange learning materials, in the form of advanced learning objects, including (new) pedagogical models as they emerge. Using standardized descriptions of learning objects and interfaces, learning management systems are able to connect and to facilitate simplified access to learning resources in a distributed environment. At the same time these environments can support and integrate knowledge work and learning, supporting human

resource management and company profile development. Special business models and processes are needed to integrate life-long learning into the work process and to build a viable infrastructure of E-Learning technology, service and content providers in Europe..



PROLEARN Work Packages

Research Issues in Detail

The following sections will describe the seven key areas and the research issues involved in greater detail, including appropriate references, objectives and key research issues.

Personalized Adaptive Learning

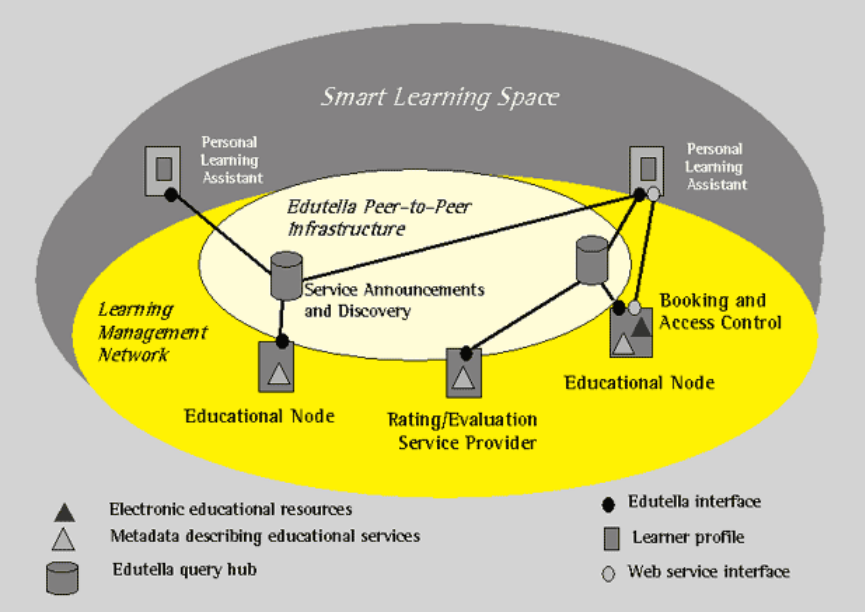
Personalized learning focuses on improving the efficiency and cost-effectiveness of learning, for individuals and organizations, independent of time, place and pace, through the development of open systems and services in support of ubiquitous, experiential and contextualized learning and virtual collaborative learning communities. An important issue to realize the potential of personalized and adaptive learning is to integrate the variety of perspectives on personalized and adaptive learning: Psychological Backgrounds, Diagnostics, Models of Competence, Personality, Knowledge, Social Psychology; Cognitive Science, Models of Cognition, Linguistic Approaches, Artificial Intelligence, Computer Science Approaches, User Modelling, User Tracking, Profiling, Machine Learning Methods, Business Applications of Personalization Tools, Human Resource Management, Employee Self Services, Business Processes underlying Personalization. This integration can build on a sound body of work in these areas, including (Naeve 2001) (Allert & Richter 2002) (Weber & Brusilovsky 2001) (DiNitto et al. 2003) (Matera et al. 2003) (Senicar et al. 2003) (Vrabic & Simon 2001) (Geoffroy et al. 2002) (Wiley 2001) (Furstenberg et al. 2001) (Adelsberger et al. 2001) (Dolog et al. 2003), (Hochgerner et al. 1994) and (Cooper et al. 2000). The PROLEARN sponsored 3rd International Conference on Adaptive Hypermedia and Adaptive Web-Based Systems being organized in Eindhoven in August 2004 will be a major forum for these efforts.

Key Research Issues

Pedagogical models and learning theories for corporate learning: The focus here is on the development of new pedagogical models for e-Learning, mobile learning, learning on demand and for life long professional learning in general. Learning scenarios for different work processes and for learning/working situations will be considered in the PROLEARN Network, taking into account different roles that learners may perform. Communities building amongst the learners, collaborative learning as well as blended learning have proven to be adequate. Further research on learning theories and refinement of the constructivist learning model for the corporate learning environment will go on. The impact of e-Learning, mobile learning and learning on demand on society will be analysed and considered according to different target groups with specific needs. Beside technological ones also social and pedagogical approaches will be emphasized. Based on evaluation of work place performance needs pedagogical models

and learning theories can then be proposed that are based on competence management, individual gap analysis and goal oriented learning to shorten acquisition of new skills.

Standardized learning solutions and personalization: Especially for reusability and technical integration aspects the interoperability of learning content is essential. The standardisation of learning content and content engineering processes today is the basis for personalized services of tomorrow. Standardized descriptions and the possibility to search learning object repositories therefore need to be extended and closely interrelated with methods for personalized learning support. PROLEARN partners will contribute to the development of standards by analysing user requirements and feeding them into the appropriate standards body as well as by contributing specifications to the standards organizations, as base documents for the development of consensus for finalized standards.



ELENA Personalized Learning Space

Adaptive learning and assessment in open environments: Open and distributed environments provide us with many learning resources that can be potentially shared and reused in different contexts, different learning situations, and by learners with different background. The learning resources should have appropriate interface for connecting them to different services. The learning services can be customized for particular learners by selecting appropriate resources and packaging them into final services. To enable such adaptive services we need models of static structure of learning services taking reusability into account, models of service behaviour taking learner model into account, mechanisms for adapting the learning services and resources to multi-modal interfaces, mechanisms for interpreting service behaviour by particular service provider or a learner peer, techniques and methods for adaptive configuration and packaging of learning resources within learning services. Semantic web technologies together with competence ontologies can help to design and implement adaptive and cooperative learning in a portable and platform independent way. Social recommendation techniques can help in exploiting similarities between learners to suggest potentially relevant learning objects that might not be found by explicit search.

One of the key issues in a learning system is the assessment of the acquired knowledge. One of the activities will focus on the theoretical foundation of assessment, and the development of new assessment tools that can be used in open environments to construct exercise repositories. Assessment can be greatly improved by using personalization techniques to guarantee that the exercises posed are suited to the student. On the other hand, the development of open and reusable assessment tools will contribute to increase the modularity of the learning system, allow the comparison of the results obtained with different tutorial strategies, and contribute to the standardization of results obtained.

Learner modelling: To provide personalized, adaptive learning, learner modelling tools must track learner's activity and interactions with the learning material, analyse the feedback, identify the needs or interests, and evaluate the psychological profile as well as the learning style. Modern context-adaptive systems employ generic and mobile user models to provide human centred and ubiquitous services. Learners can be modelled by various peers and learning service providers in a distributed network. The key research issues in this area are: interoperable learner model artefacts, techniques for describing such artefacts, methods for extracting relevant learner model parts for particular learning situations or services, techniques for exchanging and communicating such artefacts. Personalisation procedures benefit from learner models which enclose observations from different

sources, for example observations of user interaction, learner self-reflection, or peer reflections. Diagnosis procedure methods for externalizing learner model artefacts, techniques for accessing, manipulating and processing learner model parts from different perspectives are important issues in this regard. Lerner models will also need to include situated learning in the context of work where learning is an integrated part of working (learning on demand). User competence profile will be taken into account, group modelling and pattern recognition in the user behaviour will be analysed.

User interface: The delivery of e-Learning content on different target devices and into different learning contexts is a highly challenging task. Corporate e-Learning scenarios give a rich and realistic chance to learn about the real added value of mobile services and situated learning tools. Based on pedagogical models of situated learning and cognition a wide application field can be defined to adapt the selection of learning tools and the customization of learning content to individuals. To allow the learner to take control of the personalization process in a responsible, flexible and empowering way we want to investigate the use of information visualization. Expert and expertise locators should support personalised discovery. Another promising technique to achieve adaptive behavior human-machine interaction are didactic plans based on story boards. These story boards usually consist of scenes and scenes may be recursively divided into subscenes. In this way, a space of paths is determined – the so-called story space. Another important aspect related to distributed and ubiquitous cooperative environments is the ability to deal with multi-device and multi-modal interfaces. In general, we envision the user to use a variety of devices to access an e-Learning infrastructure. Users have to be able to work and learn in sessions in which they seamlessly transit from one kind of device to another in different situations while interacting with the community.

Privacy and data protection: Important topics in this context are privacy threats of personalisation and technology enhanced learning in general, such as linkability of data, observability of data, identity disclosure, or data disclosure. PROLEARN partners will identify and evaluate privacy enhancing technologies, e.g. identity protectors, that should be integrated in learning solutions or that are missing in technology enhanced learning, and explore identity management in this area. Conflicts with personalization activities, such as activity tracking, also have to be dealt with. This includes dealing with the questions of how to protect users' data and which security technologies are the best choice to achieve data confidentiality and integrity, also from a user acceptance point of view.

Evaluation of personalization and adaptation methods: Evaluation and return on investment analysis are an important factor for the introduction of e-Learning solutions at the workplace. This includes the identification of enterprises requirements and of the main success factors for E-Learning in corporate environments. Other questions are to determine the real impact of technology-enhanced learning on individual and organizational levels, how to measure this impact, and how organizational issues and community culture influence the success of E-Learning in different environments.

Interactive Media

E-Learning can provide a much more interactive experience for the professional learner than the traditional book or training lecture. Academics understand that learning is an active and constructive process and typically aim to design learning experiences that leverage the learner's interactions (Enlund 2001) (Law et al. 2000) (Müller et at. 2002) (Nearle & Carroll 1999). Typical corporate "training" can be less interactive! Even an idealized face-to-face learning experience can be judged by how the student interacts with the teacher, other learners and the content (Eisenstadt & Vincent 2000). However, it is still the case that both professional and academic learning requires much more effective E-Learning media production, management and sharing. For instance, complex learning assets like video are still difficult to manage and transport effectively to learners (Fankhauser et al. 1999). Even the simplest of interactive media productions systems (Quemada et al. 2003) (Barbieri & Paolini 1999) (Müller & Ottmann 2000) (Fiehn et al. 2003) (Mukhopadhyay & Smith 1999) can be expensive to use and difficult to maintain and develop (Cisco 2002) (Scott & Quick 2002).

PROLEARN will thus specifically focus on expanding the professional learners' engagement with the best of European Interactive Media research to help create a more effective learning experience through technology enhanced learning.

Key Research Issues

Corporate training still needs effective competence mapping and performance evaluation tools to support business learners. Indeed, corporate clients actually need the same access as all learners to an ideal portal learning system: ie. that will offer them a tracked experience with a set of "10 Euro" learning modules, complete with credits and real interaction with peers, tutors and content; anywhere, anytime. Interactive Multimedia is improving as development environments mature. The best educationalists are now able to design media experiences for learners to achieve that "click-you-back". One critical feature which distinguishes quality media designs, from blended learning providers, is their commitment to materials that fully engage the learner in the learning process. Overall, there are three threads of research questions for both synchronous and asynchronous interactive media:

Understanding the online learning context. Which blend of the existing and innovative technologies are appropriate for different professional learners? At which level should they be integrated? How do we provide support for knowledge management and decision making in an appropriate context? How can E-Learning tools help us to produce and represent knowledge differently? How can E-Learning and traditional (existing) learning can be blended, integrated, mutually leveraged in a given context?

Understanding the social and shared learning environment. Which are the strategies to overcome the separation between technology and pedagogy, to achieve a truly interweaving between both? How cooperation between all actors in an e-learning environment can be efficiently and effectively augmented? How do we structure the underlying discussions? How do we collect and disseminate data, information and knowledge produced by diverse sources? How do we integrate knowledge management, decision making, argumentation and simulation issues in the e-learning context? How do we model interactive media for the above purposes?

Understanding the learning process: Which are the foundations of interactive media production and how do they contribute to the learning process? Which media semantics and ontologies we need to define? How can we best associate / integrate knowledge with the learning process? Which are the appropriate learning methods that take advantage of the unique features of E-Learning tools? Which are the appropriate methods to extract, exchange and share individual experience via E-Learning?

PROLEARN Activities

8 top themes arise from the research issues noted above: streaming Interactive Video content creation and management; purposing interactive media for mobile learners; remote presence and shared cooperative learning; a semantic workspace for interactive media content and management; intelligent agency for knowledgable media; empowering learners to capture and share their own content; interacting with 3D and time based content; effective live telepresence for learning systems. For three of these issues we will give a more detailed insight below.

Excellence in Streaming Interactive Video: Based on already existing and upcoming technology, e.g. the Stadium project of the Knowledge Media Institute, OU UK (eg. see the AMC system in Greece, PROLEARN-tv, or http://kmi.open.ac.uk/stadium/), it is necessary to explore and advance its utilisation in the professional workspace. Also, allowing learners to skim content and to annotate it (e.g., virtual "sticky notes") is an important further research issue. Therefore the integration with existing and upcoming support systems (eg. the work of the Freiburg Multimedia Research group research – see e.g. http://ad.informatik.uni-freiburg.de/aof) will advance the usability of these systems. Also, by combination of streaming technology with interactive course generation like the MEDIT (Multimedia Environment for Distributed Interactive Teaching) project of the EPFL group in Switzerland which provides a generic platform for the generation of interactive courses on the Web, the issue of advanced streaming content will further advance. Emphasis is placed on the experimentation of innovative pedagogic concepts based on the use and, reuse of information through hypermedia dynamic documents.

PROLEARN TV and PROLEARN Mobile

Further examples of projects in the area of streaming content are the ISABEL project at UPM in Spain, the Classroom 2000, a Swiss national project sponsored by the Swiss National Foundation and coordinated by the FPIT (Formation Postgrade en Informatique et Telecommunication) through which they run a wide range of courses dedicated to continuing education in industry. Similarly, the CASE centre run by the DEI, Polimi, which is involved in a very similar project funded by the European Social Fund –Teleacademy. As a collaborative initiative developed in synergy with the local industry partners, Teleacademy aims

at establishing a system of E-Learning addressed and accessible to different users: (non-)working and senior students and employees of the local corporate using streaming media.

Interactive Media for Mobile learning: Many professional eLearners are enthusiastic about the possibility of accessing learning materials on demand via mobile devices such as phones and PDAs. One critical virtue of the technology is that it helps a learner to prepare for synchronous learning such as lectures and to work asynchronously when they rehearse or extend upon the lecture at available time-pockets during the day. Here, experience of designing and repurposing content for alternative media platforms, such as phones and PDAs needs to be refocused on the critical requirements for the professional elearner. Examples of ongoing projects in this area are the mLearning project of KTH, Sweden who have experimental systems for interactive media on mobile devices and the work on user interfaces by the team at Albert-Ludwigs-Universität.

Presence and Shared Cooperative Learning: It has always been difficult to bring learners together in collaborative systems that are sufficiently lightweight to run on the networks and machines typically available to SMEs and non-technically focused European Corporations. Integrating knowledge about the location, state and presence of remote learners is a very significant new light on the E-Learning horizon. Two of the fastest-growing areas of Internet and mobile device usage are 'Presence' (knowing about the existence, availability, activity status, and location of others) and 'Instant Messaging' (point-to-point just-in-time text or voice communication). Thus rapid lightweight collaboration media can foster group learning interactions and productive learning behaviours. Of particular interest is the role of graphical metaphors for presence, including maps, logical layouts such as building schematics, and abstract artistic layouts such as graffiti walls. Recent experiences show that open discussion forums or instant messengers that are isolated from the content modules are rarely used. Thus, if a learner has a question about some part of a audio-visual learning object they must be able to jump directly from that context to an interaction. Our shared belief is that the synchronous presence of colleagues, both near and far, enhances not only the emotional well-being of isolated workers, but also enhances problem solving performance and learning outcomes.

Online Experiments

Professional learning requires learning content that is relevant to the working context and active learning forms that build up not only factual but applicable knowledge. Laboratories are important elements in science, engineering and technical education (Ceri et al. 1998) (Gillet et al. 2003) (Salzmann 2002) (Hesselink 2002) (Law & Babich 2003). They allow the application and testing of theoretical knowledge in practical learning situations (Faltin et al. 2002). These interactions can involve local, remote or virtual laboratories. In a local laboratory, students operate real devices and manipulate and measure real objects while being directly co-located with the devices and objects in the same room. In a remote laboratory students and devices are at different locations and students work through a computer that is connected online to a real experiment device. Virtual laboratories contain software simulations of experiments and pre-recorded measurements, pictures and videos, possibly as learning objects associated with metadata (Pastor et al. 2003) (Tuttas & Wagner 2001), but do not manipulate real objects. They can be realized as local or distributed software applications.

Active working with artifacts and problem solving does help learners to acquire applicable knowledge that can be used in practical situations. That is why courses in the sciences and engineering incorporate experimentation as an essential part of educating students. Active learning by means of virtual and remote laboratories is especially valuable for distance education students and professional learners in the workplace as they can access the labs without travelling. This flexibility is important for life long learning in professional learning, because this allows learners in the workplace to fit learning phases into a full work agenda. Until recently, experimentation required close proximity between students and equipment in special, often expensive, laboratory space. The high cost of constructing, outfitting and maintaining laboratories have often prevented students from getting access to facilities of critical importance to their education. Using remote control of real labs or software simulation of experiments has the potential of removing the obstacles of cost, time-inefficient use of facilities, inadequate technical support and limited access by students to laboratories. Professional learning students in all European countries will benefit from a large pool of online laboratories. The European-wide availability of laboratories will especially benefit students in less developed countries where few laboratories are available today.

Remote and virtual laboratories can support group work over the internet from multiple locations. Removing the geographic proximity restriction has far reaching consequences for education. Automated facilities can be shared by students working from distant locations, 24 hours a day. This increase in efficiency of laboratory operation reduces the cost per student teaching hour, makes the laboratory equipment available to a larger pool of students thereby enhancing their educational experience. It also allows teachers in the classroom to illustrate theoretical concepts with real, remotely controlled laboratory experiments or simulations. Compared with local laboratories, remote and virtual laboratories open the potential for flexible learning, access to a large number of experiments and cost savings through laboratory sharing.

Key research issues

Good user experience in authenticity, usability and cooperation: Remotely controlled experiments allow learners to work with real objects. But few such laboratories give learners the feeling of being in the lab, of working at a distant location and influencing reality. But this feeling of authenticity is important to raise and sustain intrinsic learning motivation. We have to find ways to increase perception of the experiment and its environment and to provide highly visual and interactive feedback. Today's online laboratories provide the necessary access to manipulate probes and make measurements. But they often have a poor user interface so it is difficult to use them. There is a need to improve the usability of virtual and remote laboratories because otherwise learners may quickly get frustrated and stop working with the lab. Learners need to cooperate with other remote learners and a tutor to solve demanding experimental and constructive tasks. We seek to identify successful technical and organizational settings for such cooperative learning.

Sharing and integration of European online laboratories: Many remote and virtual laboratories have been developed in pilot projects during the last years. But it is difficult for a learner to access and to use them as they are not integrated into a common framework. They differ widely in their user interface, user management and time reservation scheme. This is also the case for support functions like making notes, data recording and data processing. Communication with remotely located students and trainers is not standardized either. A joint technical framework for online laboratories will allow laboratory developers to concentrate on a specific part of the laboratory and to provide a component of high quality. The online laboratories can then form a large coherent network that is accessible through a central portal. Each laboratory in this network can easily be used by learners once they have mastered the first laboratory and understood the common basic principles. Training organizations for professional learning will find it much easier to identify and integrate online laboratories into their courses.

Access to Excellence and high quality laboratories: Most of today's online laboratories were developed as prototypes in university projects. They serve well to demonstrate the feasibility of virtual and remote experimentation and to gain experience in their use in courses at universities. But there is still a long way to go to make them reliable and robust for 24-hours use by anonymous distant users. High quality and reliable online laboratories will be welcomed and integrated into their courses by training organizations for professional learning. Most online laboratories are currently used in science and engineering education at universities. The challenge is to provide laboratories for new user groups in professional learning. For example skilled workers can get training in operating new machinery by working with such machinery in a remotely controlled laboratory. Here they could benefit from the flexible access to remote and virtual laboratories, largely independent from time and place.

Learning Objects, Metadata and Standards

In recent years, research has focused on the notion of reusable multimedia content components, called "learning objects". The basic idea is that reuse of such components can lead to important savings in time and money, and enhance the quality of digital learning experiences: the end result is faster, cheaper and better learning. These developments are further amplified and accelerated by the standardization work on "Learning Object Metadata" or LOM, based on earlier work in ARIADNE and IMS, and integrated into the SCORM reference model, taking into account initiatives like the Semantic Web (Naeve et al. 2001) (Naeve et al. 2002) (Nilsson 2001). As a consequence, learning objects are beginning to be applied in corporate contexts and support in commercial products is spreading (Nillson et al. 2002). However, the transition process from more conventional approaches is not always gradual and easy (Simon & Quemada 2002). Moreover, many initiatives still take a rather narrow and traditional view of what learning objects are and how they can be put to use, often equating them with conventional documents.

As Europe has been at the forefront of many of the developments in this area, and as activities involve many of the leading organizations in the field (ARIADNE, EDUTELLA, UNIVERSAL, IMS…), some of which are deeply involved in global standardization, there is an excellent opportunity for truly relevant collaboration that can have a high impact on the state of research and practice.

Key Research Issues

Learning object taxonomy and component architecture: In order to sharpen the very definition of learning objects, taxonomies are needed to identify different kinds of learning objects and their components, based on granularity, the level of specificity, etc. In order to realize the full potential of dynamic composition of learning object components, it is necessary to develop a flexible architecture that enables structuring of learning objects and their components: this work can start from IMS Content Packaging and Learning Design, the W3C SMIL standard, etc. and is closely related to the filed of personalized adaptive learning interactions between learning objects and their components: One approach is based on component technologies (like JavaBeans).

An alternative approach relies on web services that enable publishing of learning objects in UDDI registries, with the definition of their services through WSDL.

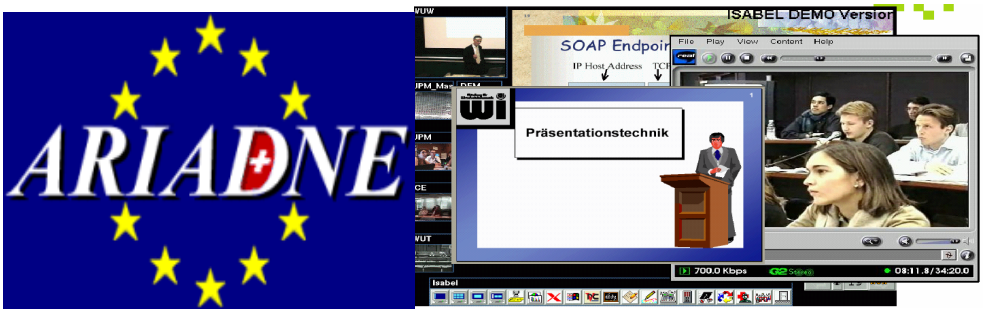
Empirical analysis: Empirical data about the actual use that is made of metadata, by different classes of end users will further our understanding of actual use cases. Useful approaches include log analysis of learning object repositories, usability studies of Learning Object (Metadata) tools, analysis of the actual content of learning object repositories (kind of learning objects, actual metadata, actual amount of reuse, actual annotations by users, etc.).

Design for and authoring by reuse, automatic metadata: Deep questions remain about the "glue" to be put between learning object components, automatic decomposition of conventional learning objects, design methodologies for reuse and the instantiation of reusable generic objects in objects that are more specific to a particular learning context. We also need to investigate how metadata can be generated (semi-) automatically, based on information about the author, the content itself, the context of use, related learning objects, etc. In this context, automatic transformation of MPEG-7 or Dublin Core metadata into LOM is highly relevant, as well as the use of application profiles such as CANCORE.

Semantic interoperability: In order to support the evolution towards semantic-based knowledge systems, we need to complement the technical interoperability with "semantic interoperability". This includes making available information about the data elements and value spaces adopted by the components in the global infrastructure, in a way that can be processed by software agents and other Semantic Web-enabled applications. It also includes examining how to make the relations between different data elements and value spaces available to such applications, thereby enabling semantic extension and refinement of vocabularies. In this context, ontology based approaches will also be considered.

Brokerage Systems and Learning Management

Today's technology-enhanced learning landscape is characterized by a huge number of heterogeneous content and service repositories (commonly referred to as learning resources) (Guth et a. 2001)(Jerman Blazic 2000) (Eberhart et al. 2000). Users either need to switch between many different systems, or they simply stick with one (meaning strong restrictions). The existence of brokers or marketplaces which integrate the existing repositories, thus creating completely new services, would be extremely beneficial for the knowledge society as a whole (Cooper et al. 2002), but especially for (small and medium) enterprise whose success relies on a workforce educated to the best-possible standards.



ARIADNE, EducaNext and ISABEL

To support the creation of such brokers, infrastructures are needed which support access to generic and reusable learning resources, and at the same time support the process of organizing the development of generic materials and services for a given company in such a way as to meet its specific requirements in an efficient way, minimizing the efforts required by learning resource providers. For references to and systems in more detail see (Balzarotti et al. 2002) (Murphy et al 1999) (Schmitz et al. 2002) (Nejdl et al. 2002a) (Nejdl et al. 2002b) (Nejdl et al. 2002c) (Nejdl et al. 2003) (Ehrig 2003) (Paulsson & Naeve 2003) (Maedche et a. 2003). Research needs to expanded in this area onwards from the technological (by creating new system interfaces for learning repositories and services) (Kraemer & Sprenger 2001), socio-economical (by showing ways to remove legal and organizational obstacles for common usage), and pedagogical frontiers (by creating guidelines for learning service creation and selection) (Rudestam & Schoenholtz-Ried 2002).

A particular emphasis needs to be put on the design, creation and deployment of electronic brokers/marketplaces for learning resources and the management of learning processes within corporations. We need to work on concept-based access mechanism to learning resource repositories and their interoperability, as well as on integrated global learning resource repositories, where the user is capable of accessing learning resources at the various levels of specification, and which support the actual delivery of learning resources, adjusted to the needs and profiles of specific organizations.

Key Research Issues

How can repositories be made interoperable, how can we support open content? Learning repositories have to be interoperable at the process level, open repositories capable of announcing and delivering learning resources to different kinds of end users and into different learning scenarios. Content production still is one of the main bottlenecks for the progress of Information Society, and we believe that open collaborative content production over the Internet can play the same role that "open software" has played in software production, given the right infrastructures and communities. However, a lively exchange of knowledge requires new distribution models securing the interests of providers (e.g. reputation, ownership, commercial prosperity) while being attractive for consumers. It is crucial to identify critical hindering and success factors for such knowledge exchange communities, as well as for supporting the creation and proliferation of learner communities and networks.

How can the management of learning processes be organized in a flexible manner? Learning, just like other human activities, cannot and will not be confined within rigidly defined boundaries such as course systems or learning repositories. A learning environment has to support trust building and rich forms of communication within and between all forms of knowledge workers, including teachers and learners.

Business Models, Processes, Markets

Progress in the field of E-Learning has focused mainly, over the last few years, on the areas of technical infrastructure and pedagogical innovation. As the demand for access to E-Learning-services is growing rapidly, in OECD countries, particularly in Asia, as well as in developing countries, for the corporate worker as well as for the individual citizen, it is increasingly important that sustainable models emerge for market players (Jung & Fischer 2002), such as service-providers, users (companies and individual learners at home) policy makers and market regulators (Beinhauer 2002). Extending research with the focus on economic feasibility, commercial relevance, usability and educational benefits, is a key success factor to enhance the competitiveness of the European eLearning industry and European society as a whole (Brantner et al. 2001).

PROLEARN will therefore provide the market players, especially SMEs as users and as service providers, with market reference models adapted to the user requirements. Based on these models, the development of streamlined general processes and tools to measure the effectiveness will increase the efficiency and ensure the necessary economical success. An essential input for these models is a thorough understanding of the specific E-Learning market mechanisms within the EU, in comparison with the North American or the Asia/Pacific markets.

Key Research Issues

Analysis of business models for providers: Advanced technological possibilities, especially mobile and broadband learning solutions, will change today's blended learning scenarios in a sustainable way within the next years. The provision of E-Learning services will grow substantially, to satisfy the growing demand of the different user groups. The business models for the service providers are therefore a critical issue in order to achieve a harmonious market development with profitable companies, and to avoid the costly mistakes made by Internet start-up companies. As a result, the business models which are defined, identified and analysed must be validated in appropriate markets. The problem is even more acute for traditional service providers, such as HEIs. While new entrants are not restricted by legal, financial or organizational constraints inherited from the past, HEIs have to take into account many conflicts of interest. As an example, the search for (technological) innovation and the claim for (academic) independence are in contradiction with the (institutional) need for reliable technological, organizational and financial frameworks - or business models -. In addition, the predominant mode of financing for projects in technology enhanced learning complies with the traditional rules of third-party research funding – not with the needs for capital of a developing company. As a result, common practice challenges both the sustainability of ICT in higher education and the every-day viability of tools and platforms used.

Analysis of business process engineering and management for users: As the technical roadblocks for technology enhanced learning are removed and as it becomes affordable to European companies and, therefore, more commonplace, the efficiency of business processes in corporate training (the 'learning processes') will be of great interest. Therefore, reference models are needed that aim at optimizing organizational and financial matters of the learning process while preserving the degree of academic excellence required by the consumer.

Knowledge Work Management

For Europe's enterprises it is necessary to be more effective and efficient in their work in order to be more competitive. At the same time, these companies (often SMEs) depend more and more on their intellectual capabilities than on their physical assets, often specialising in knowledge intensive products (Bullinger & Gidion 1995). From our point of view, work processes are also enablers for professional learning. In a knowledge-based organisation the knowledge workers, organisational processes and the infrastructure have to be arranged in a way that learning incentives are composed to cope with the consequences of insecurity and

information gaps in open & undefined work tasks (e.g. Abel et al. 2002). Trends in Europe include a shift to more and more knowledge intensive products and services, company cultures becoming strongly related to managing knowledge, revenue loss due to missing knowledge exchange between manufacturing and R&D, and continuous outsourcing of manufacturing capabilities opening a wide gap regarding information and knowledge transfer between engineering and manufacturing.

With "knowledge work" we refer to situations where the persons involved have to cope with work tasks which are complex or new at least to the person concerned in professional work. This requires a large variety of information and sound knowledge as a raw material and generates new knowledge as a product (Spath et al. 2002b). Knowledge work processes include such activities as research and product development, advertising, education, and professional services like law, accounting, and consulting (Holzschuh & Karapidis 2002). Expected long-term benefits by knowledge work management include cost reduction due to greater efficiency (Spath et al. 2002a), improved business processes and products due to better use of staff knowledge and more efficient task performance. The analysis and discussions carried out within will lead to a better understanding of the nature of knowledge work and to practice-oriented solutions for supporting the growth and innovation processes in enterprises.

Key research issues

The discipline of work design faces a fundamental dilemma: Increased productivity involves specialisation, standardisation and an increased degree of routine, i.e. a reduction of complexity. On the other hand, the innovative ability of knowledge-intensive enterprises and the competence development of knowledge workers require an increased complexity of tasks. It is necessary to consider the complete working system (competence, staff, work, technology, organisation):.

New work organisation: New forms of work division (in and between companies e.g. knowledge work and decision making in interlocking learning environments) are necessary, combining research on the previously stated areas enables the design of socio-technological systems that assist knowledge workers in acquiring knowledge and support their collaboration.

Knowledge product management and organisational learning: An important issue is the selection, design and implementation of knowledge management tools to support knowledge work as key elements, to allow us to embed individualized learning into the normal, everyday activity of knowledge workers in public and private institutions is crucial. Incorporating richer and well-structured metadata based on Semantic Web technologies will be an important ingredient, to create an environment in which human and machine agents communicate on a semantic basis. This also involves to incorporate further semantics into the corporate learning-cycle and enrich the shared understanding of all elements within the process (learning objects, student profiles, competencies, etc). Integration with personalisation and adaptation techniques enable efficient, just-in-time, personalized learning.

Competence development: Design of new Human Resources management for knowledge workers includes new career concepts, skill management and life-long learning. A special focus will be how to assess and fulfil the training needs, interaction between competence development and the mutability of companies and roles needs further investigation in order to define new ways of HR management based on information and requirements related to the organisational, social and psychological issues of the new ways of working. This key issue will result in in-depth analyses of new career concepts, including outplacements, SOHO, and virtual offices etc.

Performance & Productivity Management: The definition of knowledge e-work includes quality criteria and standardization of knowledge e-work processes, to interweave knowledge with the learning process as well as evaluate economic and usability aspects. Establishing an evaluation and benchmarking model for knowledge work companies is an important step in this direction, as well as developing an optimised and standardized business & service engineering process model for knowledge work management approaches, specifically take benchmarks evaluating usability aspects into account.

Conclusion

European E-Learning Research and Development has strongly influenced the advance of state of the art E-Learning environments and innovative E-Learning scenarios in the last years, and, through joint initiatives of European research and industry, will continue and increase E-Learning potentials and benefits in the years to come. The PROLEARN Network of Excellence in Technology Enhanced Learning, funded by the European Union in the context of the new 6th IST Framework Programme is focussing on a set of key issues, in a large concerted effort of more than 120 research institutions and companies working together in the PROLEARN Consortium and as PROLEARN Associated Partners. Interactivity in E-Learning environments will strongly be supported by interactive media and hands-on experiences. Learning will become a personalized and an adaptive learning experience, and interweaved brokerage and learning management systems will provide learning objects and resources utilizing standard interfaces and metadata. Knowledge work management will support human resource development in companies and integrate learning into workplace scenarios, and innovative E-learning business models and networks will help identify and create new markets for European industry.

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