Trends and Issues in E-learning Infrastructure Development

A White Paper for alt-i-lab 2004

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1 Introduction

The principal aim of this White Paper is to providing a summary of current trends in the development of e-learning technical infrastructure, with a view to provide feedback to a wide range of stakeholders interested in extending the boundaries of enriched technology-enabled learning.

It is acknowledged at the outset that pedagogical considerations and business processes to facilitate learning, however defined, are of paramount concern in developing e-learning infrastructure, but these matters are outside the immediate scope of this White Paper which limits itself to a description of current technical trends and issues, rather than pedagogical factors.

There is an underlying assumption in this paper however, that infrastructure in its various manifestations should be the enabler for process-centric learning whether managed by organisations, communities of interest or individuals.

The term “infrastructure” is highly contextual in its meaning. In e-learning contexts “e-learning infrastructure”, “technical infrastructure”, and “ICT infrastructure” all convey a range of meanings. For the technically inclined, “infrastructure” often describes a bottom “layer” of an architectural description or diagram, indicating network hardware components, communications processes, services and protocols. However, for others, it can also serve as a label that includes the “applications layers” or even more broadly, the entire platform required to deliver services.

It is acknowledged also that there is no easy way of defining the boundaries of e-learning technical infrastructure. As with any new industry there has been a proliferation of initiatives a proliferation of initiatives aimed at describing and/or modelling the technical components required to assemble robust and sustainable ICT infrastructure to support learning, education and training. For the purposes of this paper ‘infrastructure’ describes everything that supports both the flow and processing of information, including but not limited to, hardware, software, protocols etc.

The rapid development of a new industry, such as that pertaining to e-learning, inevitably leads to a large amount of new, recycled and often inconsistent use of terminology. Even the term “e-learning” is problematic, despite having widespread adoption and utility. One of the key issues concerning e-learning is identifying its distinguishing characteristics or in defining the boundaries within which it is conducted. Does e-learning depend upon engagement with purposed “learning content”? Is it an activity that is necessarily online? Does it require the support of a Learning Management System, a Managed Learning Environment, an integrated portal service, or any other purpose-built application software? Does e-learning depend upon computer networks? Or is it an activity that is defined by engagement with information and communications technology (ICT) more broadly? What distinguishes e-learning activities, if at all, from other activities associated with learning, education, or training – such as scholarly research, information seeking, information browsing, sense-making, or knowledge sharing – especially when many of these activities are enabled by ICT infrastructure?

There is no right or wrong way of interpreting any of these questions and this White Paper adopts no particular stance on these issues, knowing that better understanding will emerge over time as the industry matures.

The appendix to this White Paper details materials that illustrate or provide supporting documentation for the key trends and issues identified. It should be noted that the examples of current trends and initiatives are not in any sense meant to be exhaustive, but merely illustrative of various approaches to the development of e-learning technical infrastructure.

The White Paper is intended to provide a state of play overview rather than a state of the art commentary with a view to raising questions about the future. There is a tendency for futurists to look for the so-called "killer app" that makes e-learning really become ubiquitous. This paper does not intend to make any such predications. In spite of the various qualifications surrounding the scope of this paper the hope is that it will stimulate more concentrated debate so as to assist all stakeholders in making considered judgements in a field that continues to be full of uncertainties.

2 Trends and Issues

Because there exists an ever-increasing range of information and communications technologies (ICT[1]) the range of options that facilitate learning is likewise increasing. Participants in learning already have many choices in terms of how they engage with ICT, and encounter ICT across a full range of activities in work and leisure.

An increasing proportion of learners are 'digital natives' whose thought processes, socialization and engagement with ICT differs radically from that of previous generations. Google queries; ad hoc surfing of the Web; numerous messaging and interaction technologies (email, web-forums, and real-time chat); personal weblogs; collaborative websites such as wikis; research tools that enable the classification and clustering of queried results on the fly; purchase of goods and services, sophisticated virtual reality and simulation environments; gaming and role-play applications are not only the daily experience and key methods of interaction for the digital native, but they are both the normal expectation and historical experience.

Moreover, there is an increasing range of user interfaces, physical devices and supporting infrastructure that facilitate this engagement.

Rarely are technologies used in e-learning developed specifically for the learning community. ICT developments are harnessed to support learning. E-learning applications vary in scale and purpose and encompass a full range of engagement points from purpose built 'learning management systems' or 'virtual learning environments' that are structured around course delivery to short, just in time targeted, single purpose learning experiences, delivered in context and developed for example in Flash or Java.

[1] With the notable exception of the US many stakeholders within the education and training sector worldwide have enthusiastically embraced the term 'ICT' when referring to technologies enabling e-learning.

The range of Web-accessible technologies and services useful to learning, education, and training can be classified broadly into three categories, namely:

- Infrastructure *specifically purposed* to support learning, education, and training;
- Infrastructure that is *not specifically purposed* to support learning, education, and training *but is still essential* in enabling it; and,
- More widely deployed infrastructure that *may be useful* for learning, education, and training.

In a much broader sense infrastructure is widely applied to the totality of technologies and services that make up large scale deployments for particular learning, education, and training communities.

Given the complexities of capturing the conceptual models underpinning infrastructure development, there is no easy way of providing a succinct overview of current trends and initiatives. The following summary represents therefore a snapshot from a number of different perspectives and in doing so attempts to expose some of the key issues of relevance to both policy and technical development.

2.1 E-learning in context

E-learning has moved through a number of distinct phases – from Computer Based Training through to Learning Management Systems and Courseware Management Systems to now encompass an increasingly broad scope of applications and activity. There are a number of factors worth noting in terms of mapping the evolving e-learning landscape, including the following:

- Ongoing development in dedicated e-learning software applications, commonly known as learning management systems (LMS) or managed learning environments (MLE) has evolved where many of the early LMS vendors now offer their LMS as one application within a suite of products
- E-learning is now facilitated by an increasing range of specialised e-learning applications within the wider infrastructure and is not necessarily delivered by managed learning environment such LMS. Much of this learning happens in context, for example ‘just in time’ in the workplace
- Basic ‘units of learning’ or ‘units of instruction’ are beginning to shift away from the traditional course model (courseware) to typically smaller, more targeted, modules (learningware).
- Portals are widely adopted in e-learning.
- Publishers are now offering value added services to the e-learning market – examples include McGraw-Hill who are offering a free Course Management System (PageOut) and Thomson Learning’s TextChoice provides easy access to digital content from which teachers can create custom learning materials
- ‘M-learning’, or mobile learning, has become established as a significant area of research and development (e.g., through the European MOBILearn project). However, it also brings with it a new set of constraints that impact the design of e-learning content and applications
- Despite the increasingly important role (and diversity) of Web-enabled repositories within e-learning technical infrastructure little learning object/courseware content is contained within them.

- Acquisition and distribution of learning resources is also increasingly taking place in across distributed infrastructures in which metadata and content is shared among multiple repositories.
- Preservation and "future proofing" of e-learning content is not just an archival issue but also involves longer term value on investment. Just as content is being created in larger volumes than ever before it is also being lost through format obsolescence and poor information management practices. There needs to be consideration given toward backward compatibility and access to content in older or ageing formats
- The impact of P2P (peer-to-peer) applications in learning, education, and training is yet to occur. Important R&D projects such as EduTella and LionShare are exploring issues in the application of P2P in the domain. But it's a reasonable (and possibly disruptive) thing to expect given the huge impact that Napster and Kazaa have had not just on the distribution of digital music but also on ways in which to share it. As the number of repositories of reusable learning objects increases worldwide and the access price of such content decreases it is likely that personalized P2P approaches to learning will be well supported by a range of sources.
- Applications supporting the flexible use of and reuse of activity-based learning are now appearing in the market. These applications are as equally concerned with processes (activities, sequences of interactions, and workflow) as they are with content.
- Technical systems that support workflow and other 'knowledge management' tasks are increasingly convergent in requirements to those that support learning
- E-portfolio software is proliferating, combining features that enable trusted credentialing and management of user artifacts and collections. It is already evident, however, that the term 'e-portfolio' has already been adopted by many stakeholders in different ways – such as, a packaged personal transcript and/or CV format; repositories of personal information; stores of completed artifacts and user-controlled 'works-in-progress'; and, portable, web-enabled personal profiles. In addition to the administrative imperatives, the drivers for these developments include the desire to promote learner self-management and the independence of learning outcomes from individual institutions/sectors/companies – as well as the administrative imperatives
- Currently, context is derived from the LMS's knowledgebase and applied only within the LMS (e.g., Clicking on *My Courses* shows the course for which a learner is known to be enrolled on this LMS). Context is not shared outside of applications. When context is provided by the infrastructure (e.g., as in presence broadcast, as used by instant messaging software) contextualisation information is shared by all tools.
- Aspects of Customer Relationship Management (CRM) are starting to be adopted into learning applications. This is leading to the emergence of learning relationship management systems. CRM generally consists of integrated knowledge bases, cross-departmental communication channels, and customer intelligence gathering and dissemination – all things that can also apply to e-learning, especially of the institutional variety.

- Mind-mapping software (e.g., 3MRT) is being increasingly marketed to educational stakeholders for organizing ideas and information. Objects created from such software can be easily shared.
- Innovative query interfaces for learning object discovery are starting to appear.
- Performance support – particularly within the workplace – is shaping the design and delivery of e-learning and training. Performance support takes the form of a range of tools, including online Help, virtual reference, workflow facilitation, and productivity software, etc.
- With some notable exceptions, games targeted at learners do not appeal to the digital natives, who avidly participate in gaming for leisure. The US DOD DARWARS Training Superiority Program (DARWARS) – is a serious attempt to effectively use leading edge gaming for training (and recruitment).
- There are individuals and small groups in the learning, education and training communities developing innovative teaching applications. Many of these teaching applications are developed in isolation from institutional infrastructure and without regard to standards. These applications tend to be small-scale specialised fit for purpose applications but with limited potential for integration with the e-learning enterprise and broader reuse. The lack of integration capability results from high barriers for entry for individuals to create tools that implement open standards or provide connectivity to enterprise systems.

  The adoption of service oriented approaches (soa's), availability of toolkit and lightweight development environments (e.g., konfabulator) should lower these barriers and enable the formal e-learning infrastructure to take advantage of individual innovation and specialist knowledge and the individual innovator to develop standard compliant light applications.
- Despite the existence of innovative individuals and organisations, the formal e-learning community is relatively slow at adopting and adapting to popular leading edge user technologies.
- Adopting evolving infrastructure does not necessarily lead to transformation in learning, education and training.

2.2 Interoperability through standards development

The term interoperability has widespread currency because it is used to encapsulate the various levels of connectivity necessary to create end-to-end infrastructure linking systems and services in a meaningful way for the user. The development of standards is seen as the principal means of achieving widespread interoperability hence the interdependence of the two terms.

In an attempt to put structure around the required levels of interoperability there is a significant investment in the community in developing frameworks and architectures that provide an overall model of the infrastructure required to support e-learning. To a large extent these models are strategic rather than technical, and are used to make sense of a complex world of standards, their application in the enterprise, communicate to a constituency of stakeholders, identify gaps and prioritise engagement.

From a different perspective the business drivers for interoperability are well illustrated by the five SCORM "ilities" as value propositions for developing large-scale e-learning infrastructure: reusability, affordability, durability, accessibility, and interoperability. Sometimes, 'flexibility', 'extensibility', 'scalability', and/or 'maintainability' are added to this list. These "ilities" thus have social and political dimensions to them and are not entirely technical in nature.

From a standards point of view there are a number of observations to be made including:

- There are many 'communities' (consortia, standards bodies, research and development initiatives) working in the area of developing specifications and standards. Some of this activity is occurring in traditional 'vertical' sectors (such as education, library information services, financial services, or health) while some of it is 'horizontal' (such as the efforts of the W3C or IETF).
- The terms 'framework' and 'architecture' are used by different communities to describe a view (typically a high-level overview) of the range of functions or facets of an e-learning system or infrastructure. As such, the terms are used in both general and technical contexts. In some cases the terms have a technical meaning (though not a consistent technical interpretation) and apply to an implementation, in other cases describe a conceptual organisation of components, whilst in others define an action plan.
- There is a variety of approaches to infrastructure modeling which illustrate a strong community need to have clear models for a number of purposes including: defining a clear overview of the e-learning space as it applies to a community; defining a map for implementation of standards and specifications; supporting strategic decisions relating to infrastructure and standardization; documenting an agreed implementation set of technologies; providing an implementation and development environment, etc.
- Some of these modeling approaches and the technical implementations they infer are consistent with each other, whilst others result in implementations that will not be interoperable outside the immediately implementing community. There is a question as to whether there can or should be convergence between all these approaches.
- From a stakeholder and end-user perspective coordination of effort between standards development organizations and/or consortia is becoming necessary both across horizontal activity, within the vertical sectoral activity, and increasingly across the vertical sectors.
- The goals of 'open standards' development (openness, consensus, and due process) are increasingly gaining support from the e-learning community.
- The e-learning community has generally preferred a standardisation process that reflects acceptance and marketplace adoption of an innovation or practice. However, some standards development activity can be seen as pre-emptive – ie, as not emerging from existing practice and marketplace acceptance but as a means to map out development activity and/or secure market share. It is also true that innovation often occurs ahead of the standardization activities.
- Increased stakeholder acceptance and adoption of technical 'standards' to support learning, education, and training through industry-accepted

specifications such as those developed by the IMS and the ADL and standards such as those developed by the IEEE.

- The take up of e-learning standards to some extent is assisted by government policy. Some jurisdictions are either legislating or have policy mandates for the adoption of standards for e-learning itself or areas that impact directly on e-learning developments such as accessibility.
- The early phase of 'e-learning standards' development has been focused on data interchange associated with content and its management. The next phase is yet to clearly define itself but it is moving toward being more concerned with runtime issues, interactions, and activities on the one hand and components, behaviours, services, and frameworks on the other.
- The trend towards transactional approaches is driven by the growing acceptance of service oriented architectures and the development of Web Services standards based on XML (e.g., SOAP, WSDL, and UDDI). However, there is still much to be done in the area of Web Services standardization and the best practices for developing domain specific specifications bound to Web Services.
- In addition technical standards, the development of standards-based approaches to the classification of competencies and other vocabularies useful for e-learning need significant involvement by practitioners.
- To date, there has been little progress in the standardization of ICT-enabled pedagogical or learning activity processes. While there has been considerable effort in this area, there is a strong disconnect between experts in pedagogy, and technologists. There is active debate and a desire to make progress, but the level of infrastructure maturity is hampering the sort of experimentation that is necessary to develop practical experience that will inform the learning design. The IMS Learning Design specification, publicly released in 2003, is an initial attempt to address processes associated with learning design.
- Security, Digital Identity and Access Management (authorization, authentication, and access management) is a pain point in many communities, who are looking for appropriate standards that can be implemented across enterprise systems and between enterprises. Each step of an interaction between two systems has independent identity and access management requirements. The full solution will be quite intricate; will require a set of standards; detailed analysis of the interactions and the appropriate standard/s which apply at each step; and, the legal, social and economic considerations for the application supported.
- Digital Rights Management continues to be a problematic area of development entangled with legal, political, economic, and social issues, and interplay with Identity Management. Much of the work in the e-learning community has been focused requirements for Digital Rights Expression Languages. A separate white paper on Digital Rights Management is available.
- The notion of 'reusable content' in the e-learning community has hitherto been mostly concerned with objects as discrete and complete within a container that are either stand-alone or able to form part of a larger aggregation (such as a course). "Reuse" (recomposition/assembly) is being supported by a wide range of standards (such as IMS Content Packaging, SCORM, and IEEE LOM) as well as tools. However the requirements of learning design, interoperable repositories and learning management systems, integrated sourcing of content

components from “information” repositories, repurposing of content, content syndication, digital rights management, and accessibility support indicate a more flexible model of learning content is now is needed.

2.3 Convergence of service oriented approaches

In recent years there has been a shift from monolithic application silos toward service oriented approaches where flexible granular functional components expose services accessible to applications via loosely coupled standards-based interfaces. In the strict sense this approach is known as Service Oriented Architectures (SOA’s) which includes an assumption of delivery by Web Services. However a less formal service oriented approach (small “soa”) has usefully adapted the general approach of loosely coupled services whilst allowing for greater flexibility in the technology of implementation, and would in fact allow a service to be delivered by a “human” service provider through a manual interaction process.

There are a number of observations to be made relating to recent initiatives in this area:

- The drivers for adoption of soa’s and Web Services are not purely based on technological elegance. Reusability, lower over all costs, higher ROI’s, protection of legacy investment, lower cost of entry, rapid development, potential for business processes to drive technology are some of the key benefits being sold to managers.
- A number of communities recognize that many of the services underpinning different enterprise domains (library, e-learning, administration) are not specific to that domain, but may be common to more than one domain. . Unbundling these services from the specific application environments has led to the development of frameworks and architectures that identify ‘common services’ as a key layer. However there is little agreement between communities responsible for creating domain focused models as to the factoring of these common services, nor are there clear processes for engagement between communities to develop a common factoring.
- There is a complementary recognition that data and resources which are created and managed by one domain, are used by or could be of use to other domains. SOA has the potential to support a “create once, use many” best practice philosophy by exposing the services.
- Innovations in soa’s and Web Services are being driven by organisations need to enable business process management and support organisational flexibility. To realise this benefit requires the ability to understand and model business process in the organisation, a capability not necessarily present in research, education, learning and teaching organisations.
- Grid activity is growing, and becoming part of the mainstream vocabulary and attempts by vendors to develop markets outside the research communities. Grid Computing has three core aspects: the high powered networks which enable grids to operate; the software components that enable the power of the distributed computing power on the grid to be harnessed (for example scheduling and resource brokering); and the applications that operate across the grid. The Grid community is rapidly adopting an open architecture which includes the concepts of soa’s and Web Services.

- There has been a convergence between the Grid infrastructure community and those with applications which require the processing power the Grid can offer, particularly research and applied science dealing with large scale datasets. This converged interest is becoming known as “E-Science”.
- Middleware is the layer of technology that glues together applications and networked services i.e. interoperable “common services” and the applications which allow users to easily take advantage of these services in a networked environment
- As the focus shifts from the network to the standards for interoperability of the underlying software components, there has been convergence between the interests of the grid/e-science and middleware communities and those of other domains. However, grid/e-science and middleware communities are attracting significantly more funding to address common issues than the less sexy domains of information management and e-learning. It appears imperative that these communities urgently develop a strategy for engagement with the grid/science middleware communities.
- W3C Semantic Web R&D is now gathering momentum with some of its ‘component’ technologies being adopted for specific purposes (e.g., SMIL for multimedia streaming and OWL for ontology description and management).
- Some sections of the Grid Computing community have been pursuing a combined R&D agenda with the Semantic Web community (“The Semantic Grid”).

2.4 Networks and Connectivity

Networks and connectivity are almost universally assumed to be critical to the development of successful infrastructure. It should be noted that connectivity is not just an enabler of networks and access to content but it is an organizing principle in its own right. Connections enable relationships (involving people and services) and relationships enable networks. The ‘connected’ word (as in ‘connected learning’) is being currently adopted within policy frameworks around the world (e.g., UK and Australia) – perhaps as the next distinguishing label that follows ‘networked learning’ and ‘blended learning’.

From the technical perspective there are a number of observations to be made:

- Within the education and research sectors there has been widespread deployment of advanced broadband networks such as Internet2 and SuperJanet.
- There is a growing range of technologies which provide affordable consumer broadband connectivity options and a consequent significant penetration into this market.
- There has been rapid deployment and take up of mobile wireless data and mobile telephony high bandwidth 3G technologies. Advances such as WiMax (IEEE 802.16) providing broadband wireless connectivity for distances up to 30 miles and Internet telephony are resulting in a blurring of the two applications.
- Important innovations in satellite technology and low cost receiving antennae are making low cost direct to home satellite services increasingly available. Satellite services are advantageous where other networks are not available

(poor infrastructure or reception) and for multimedia push delivery to a large dispersed population. For example, India will be launching a dedicated satellite for education purposes in July 2004.

- Voice over IP) is a particularly interesting example of the convergence of information and communications technologies which potentially reduce costs and/or provide enhanced services which were previously prohibitively expensive.
- There is significant R&D in the application of peer-to-peer networks for learning, education, and training.
- Increased proliferation of SPAM and viruses are not only an irritant to users but are beginning to cause widespread dysfunction of systems and the corruption of data. The value proposition for security, identity and access management systems is becoming more attractive as organisations count the cost of incursion, infection, spam, phishing etc.

2.5 General application development trends

The concept of 'what an application is' is rapidly changing in an 'soa' oriented world with the move away from monolithic applications towards deploying more targeted applications which consume granular services. It remains to be seen to what extent these services become finely grained.

A key goal of SOA's is to facilitate reuse. The term 'composite applications' is used to describe the building of an application by orchestrating or assembling a range of other applications and services. Composite applications may be built from a range of domain specific and common services and from services across domains.

There are a number of observations to be made on the technologies likely to affect the development of applications, including:

- Portal technology continues to be developed in functionality and technologies as the core user interface.
- Portals are becoming the user interface for the delivery of "composite applications" and not just aggregators of contextualised services.
- Personalisation continues to be stated as a goal of user interfaces, although there is ongoing debate as to the ROI for personalisation services. The value proposition may change as personalisation is achieved through adaptive technologies based on knowledge of the user's behaviour and requirements (such as accessibility) rather than user configured preferences.
- The "top down" approach of personalisation contrasts with the popularity of networked personal tools as being the "bottom-up" method – where users are deploying, customising, and using (typically desktop) applications which are internet enabled to supply functionality – e.g., IM applications, Limewire/P2P file sharers, LiveJournal/Blogger clients, RSS readers, iTunes, etc. This is different in character from personalisation, which is about adapting an organisational viewpoint to a personal one. This trend is also very much about individual empowerment and user control. Interestingly, in an environment where security has become a major issue, wikis operate on a high level of personal trust that individual's will "do the right thing".

- An increasing choice exists in collaborative environments such as Wikis, P2P applications, messaging forums, collaboration and conferencing applications and services.
- There is an increasing number of tools and methods available for the self-publishing, annotation, syndication and community filtering/reflection syndication of content, ranging from those supporting traditional practice in the publishing world (ICE, PRISM) to the open world of RSS and ATOM.
- Innovation in blogging software development is now showing evidence of convergence toward a common core feature set based on common practice.
- Streaming technologies have become a lot more manageable and significantly cheaper to deploy in recent years.
- Ubiquitous computing ('all the time anywhere') environments are a superset of mobile computing ('anytime anywhere'). Whilst mobile computing may be location dependent, ubiquitous computing is proactively aware of, and manages context. Mobile computing implementations are steadily increasing – whether it is a wireless-enabled coffee shop or a taxi equipped with both GPS and EFT facilities.
- New mobile devices are designed to appeal to the digital native and becoming pervasive and almost "disposable".
- Simulation software and virtual reality environments have become increasingly sophisticated. Costs have been driven down whilst improving quality and realism.
- Gaming and role-playing environments are utilized by extremely large numbers of individuals either interacting with small groups (such as America's Army) or in large numbers in persistent MMORGs (massively multiplayer online role-playing games) such as Toontown or Everquest. Everquest has over 400,000 subscribers, can have over 50,000 concurrent players and had developed large virtual and real economies.
- There exists the perennial possibility that a totally new paradigm will emerge in user interaction with computing. Software such as NBOR Blackspace (a fully integrated environment) markets itself as such a revolution. Some predict that the paradigm of role-playing environments, with Avatar representations of people and virtual representations of objects will become the paradigm for the user interface for "real world" computing.
- It is not possible to predict how the community of 'digital natives' will adapt a technology or device to their own purposes.

2.6 Open Source initiatives

There has been an important growth in acceptance and support of open source software solutions by large influential stakeholder communities, such as governments and there has been a great deal of activity within academic practitioner communities in developing innovative teaching applications.

At the most general level, there are a number of observations to be made:

- The protocols and obligations associated with development of open source software have proved to be a viable development methodology which can

produce high quality software, rapid development and prototyping and matching of real-world user requirements.

- Open source software is already in abundant supply, with many domain-specific applications available. These tools vary in scale from code libraries that perform very specific tasks, toolkits for that supply underlying functions for use by user applications to large applications.
- A variety of business models are emerging for the development of open source software, services around open source software and support for communities that implement open source software.
- In e-learning, the MIT Open Courseware Initiative triggered (re)assessment of business models. The SAKAI project and the SAKAI Educational Partners Program are exploring a consortium lead development can be extended and supported as open source to a general community These two related projects employ different business models. [2]
- There has been some tendency for stakeholder communities to mistakenly view open source software as an alternative to open standards development.
- Some interesting interactions are now occurring between vendors of proprietary products and services and open source solutions.

[2] See SAKAI entry in the appendix for details.

Appendix: Selected Resources

Trends and Issues in E-learning Infrastructure Development

This annotated list presents a selected picture of global e-learning infrastructure developments and resources.

A. Infrastructure Models

There is significant investment in many e-learning communities in developing models and frameworks of the infrastructure supporting e-learning. The following selected examples represent both technical and non-technical perspectives.

Carnegie-Mellon LSAL: Learning Services Architecture
http://www.lsal.cmu.edu/lsal/expertise/projects/servicesarchitecture/index.html
"In contrast to building large, closed, learning technology systems, the focus of the learning services architecture is on a flexible design that provides interoperability of components and learning content, and that relies on open standards (both learning technology standards and common web and network standards) for information exchange, behavior descriptions and component integration. The **Learning Services Architecture** and the **Learning Services Stack** provide a framework for developing service-based and component-based learning technology systems."

Carnegie-Mellon LSAL: Content Object Repository Discovery and Registration/Resolution Architecture – CORDRA
http://www.lsal.cmu.edu/lsal/expertise/projects/cordra/intro/intro-v1p00.html
Work that is informing the direction for the next version of SCORM. "CORDRA is designed to be an enabling model to bridge the worlds of learning content management and delivery, and content repositories and digital libraries. CORDRA aims to identify and specify (not develop) appropriate technologies and existing interoperability standards that can be combined into a *reference* model."

Composite Applications: The Next Big Thing?
http://www.zdnet.com.au/insight/software/0,39023769,39151103,00.htm
C. Roth (2004), The META Group, CNET Networks

DfES e-learning Strategy (UK)
http://www.dfes.gov.uk/elearningstrategy/
This forms part of an overall UK e-Government Interoperability Framework (eGIF). Occupying a prominent place within the framework are standards: "In order to build confidence in the benefits and advantages of e-Learning from the point of view of the learner, teacher and provider, a consistent and reliable approach to technical, pedagogical and quality standards needs to be established."

Digital Training Systems Architecture
http://mdlet.jtc1sc36.org/doc/SC36_WG4_N0064.pdf
"The Digital Training System Architecture (DTSA) is a conceptual architecture, or framework, intended to illustrate how training systems at varying levels of capability -- from simple text page turning applications, to interactive context-sensitive help

systems, to simulation-based training environments, to the most sophisticated intelligent tutoring systems -- may be developed from the ground up. This approach starts simple and gradually adds capability and complexity while assuring maximum reuse.
The DTSA is not intended to direct specific implementation, or to be a standard that mandates conformance for training systems. Rather it is intended to be a guiding framework for development of various interactive training systems and environments." (John Tyler, IEEE LTSC)

EduWorks – e-Learning Strategies & Architectures
http://www.eduworks.com/g_strategies.html
Recognizes differences in requirements from key stakeholder sectors: Enterprises, Higher education, Software Providers, and Content Providers.

eEurope 2005 – e-learning
http://europa.eu.int/information_society/eeurope/2005/all_about/elearning/index_en.htm
"In a world increasingly based on knowledge and information, education and training are put at the core of the European agenda." It is explicit about moving from an "initiative" (2001-2004) to a "programme" (2004-2006).

e-learning Framework - Badrul Khan
http://www.bookstoread.com/framework/
Identifies and describes eight key dimensions of an e-learning framework:

- Pedagogical
- Technological
- Institutional
- Ethical
- Interface Design
- Resource Support
- Management
- Evaluation

eLearning Interoperability Framework for Europe (LIFE)
http://life.eun.org/
Not yet a framework! European Schoolnet launched the eLearning Interoperability Framework for Europe (LIFE) action in March 2004 with *the aim of establishing a framework* among the ministries of education in Europe and other interested partners "for common action, work and approaches towards standards and interoperability for a European e-learning area."

IBM Learning Solutions for Higher Education
http://www-903.ibm.com/kr/public/paper/white/2HigherEducation.pdf

IBM LOTUS eLearning Infrastructure
http://www-1.ibm.com/businesscenter/us/solutions/overview.jsp?solutionid=8114
Application software that offers two ways to deliver training via the Web: in real-time, virtual classrooms or in self-paced online modules.

IMS Global Consortium – Abstract Framework
http://www.imsglobal.org/af/afv1p0/imsafwhitepaperv1p0.html
"The IMS Abstract Framework is a device to enable the IMS to describe the context within which it develops its eLearning technology specifications. This framework is not an attempt to define the IMS architecture, rather it is a mechanism to define the

set of interfaces for which IMS may or may not produce a set of interoperability specifications. The IMS Abstract Framework is so named because:

- It is an abstract representation of the set of services that are used to construct an eLearning system in its broadest sense;
- It is focused on the support of distributed electronic learning systems;
- It is a framework that covers the possible range of eLearning architectures that could be constructed from the set of defined services."

JISC Frameworks Programme

http://www.jisc.ac.uk/index.cfm?name=programme_frameworks

"Although technology has the potential to extend and improve educational activities, this potential can only be fully realised if the activities are built upon a stable and coherent technical infrastructure." The aim of the Frameworks programme is to - 'Develop and evaluate a framework to facilitate interoperability across learning, teaching, research and their supporting systems.' This is an overarching programme which will build on the work of existing projects/programmes in:

- Information Environment (IE) architectural developments.
- Demonstrators of a Common Information Environment (CIE) that crosses library, research, learning and teaching, museum and archive and health infrastructures.
- Development of Managed Learning Environment (MLE) architectures.
- Explorations into a common technical framework to support e-Learning.
- Infrastructure developments to support e-Research and e-Science.

The programme will consider how the strengths of each separate area can be maximised, and to ensure that these systems can interoperate fully with each other. To deliver the strategic vision of supplying a common infrastructure the JISC will link its development initiatives to ensure that they address user requirements, avoid duplication of effort and support interoperability at local, regional, national and international level.

JISC e-learning Framework

http://www.jisc.ac.uk/index.cfm?name=elearning_framework

"The JISC has already made a considerable contribution to the development of the MLE concept and supporting interoperability standards. However there is still a need to produce a coherent vision of how to integrate systems to support institutional processes such as effective e-learning. Research in current MLE development indicates that it is expanding rapidly but that there is still a lack of pedagogical flexibility and innovation in the design of e-learning tools, environments and architectures. The JISC e-Learning Programme intends to address this issue and will focus on four themes: e-learning and pedagogy; technical framework and tools for e-learning; innovation and distributed e-learning."

Microsoft e-learning Solution for Education

http://www.microsoft.com/Education/Partner/EdPartnerELearning.aspx

Provides access to a range of technical papers describing their integrated approach and e-learning solutions architecture.

Open Architecture and Schools in Society (OASIS)

http://oasis.cnice.mecd.es

A blended learning approach that aims to leverage "the socialisation role of the traditional schooling as one of the main capacities of the traditional public system"

while facilitating the growth of the "small school virtual community around the school portal as the main tool to support this approach."

Open Grid Services Architecture
https://forge.gridforum.org/projects/ogsa-wg
"The purpose of the OGSA Working Group is to achieve an integrated approach to future OGSA service development via the documentation of requirements, functionality, priorities, and interrelationships for OGSA services."

Open Knowledge Initiative (OKI)
http://web.mit.edu/oki/
Higher education focused: "a collaboration among leading universities and specification and standards organizations to support innovative learning technology in higher education. The result of this collaboration is an open and extensible architecture that specifies how the components of an educational software environment communicate with each other and with other enterprise systems. OKI provides a modular development platform for building both traditional and innovative applications while leveraging existing and future infrastructure technologies."

Sakai
http://www.sakaiproject.org/
"The Sakai Project is a software development project founded by The University of Michigan, Indiana University, MIT, Stanford, the uPortal Consortium, and the Open Knowledge Initiative (OKI) with the support of the Andrew W. Mellon Foundation. The project is producing open source Collaboration and Learning Environment (CLE) software with the first release in July 2004. .The Sakai Educational Partners' Program (SEPP) extends this community source project to other academic institutions around the world, and is supported by the William and Flora Hewlett Foundation and SEPP member contributions"

Joseph Hardin, University of Michigan is the Principal Investigator of both projects. The two projects share a common Board of Directors.

SC36 WG5 – QA & Descriptive Frameworks
http://frameworks.jtc1sc36.org/
"The SC36/WG5 work programme addresses: describing and characterizing processes, components, and attributes related to the quality and architecture of IT-supported environments in the field of learning, education, and training. SC36 operates as a peak international body (within ISO/IEC) in the standardization of IT for learning, education, and training."

SIF – Schools Interoperability Framework
http://www.sifinfo.org/
"The Schools Interoperability Framework (SIF) is a non-profit membership organization comprised of over 100 software vendors, school districts, state departments of education and other organizations active in primary and secondary (K-12) markets, who have come together to create a set of rules and definitions to enable software programs from different companies to share information. This set of platform independent, vendor neutral rules and definitions is called the *SIF Implementation Specification*."

***Sun* eLearning Application Infrastructure**

http://www.sun.com/products-n-solutions/edu/whitepapers/pdf/eLearning_Application_Infrastructure_wp.pdf
"The purpose of this white paper is to provide a model for a basic understanding of the different services that e-learning technologies provide and how they fit together into an overall e-learning application infrastructure. The paper is oriented primarily toward the "business application" layer of the technology and provides a functional overview of the components and processes that make up an e-learning environment."

***Sun* eLEarning Reference Architecture**
http://www.sun.com/aboutsun/media/presskits/gov/344328.pdf
"The Reference Architecture is an open framework for constructing enterprise scale eLearning systems geared towards the academic sector."

B. Digital Repository Projects

There is ongoing debate concerning what constitutes a 'repository'. Repositories can be identified as 'black boxes' that just store things or as specific instantiations, such as: registries, learning object repositories, metadata repositories, institutional repositories, personal repositories, peer-to-peer repositories, digital repositories, digital libraries, and some implementations of e-portfolios. Repository management issues are closely related to the development of e-learning infrastructure.

Academic ADL Co-Lab Learning Repositories Projects Directory
http://projects.aadlcolab.org/repository-directory/
"The Academic ADL Co-Lab keeps up to date on developments in the world of learning repositories. To help ourselves to track innovations and developments, we have developed a registry of learning repository projects of interest, listing the attributes of their content as well as their policies concerning collection, metadata management, and outreach."

Align To Achieve (A2A)
http://www.aligntoachieve.com/
A registry/directory - *The Academic Standards e-Library* (TASL) - of principally US-state-based competency standards associated with the K-12 sector. Focused on mathematics, English language arts, science, and social studies from the states, national organizations, and selected countries.

ARIADNE (Alliance of Remote Instructional Authoring and Distribution Networks for Europe
http://www.ariadne-eu.org/
"The basic mission of ARIADNE is to enable better quality learning through the development of learning objects, tools and methodologies that enable a "share and reuse" approach for education and training."

CELEBRATE
http://celebrate.eun.org/
A large-scale demonstrator project funded by the European Commission designed to be a repository and exchange for learning objects and their components. "It is intended that CELEBRATE will act as a catalyst for the European eLearning content

industry (the entire value-chain including content owners, publishers, broadcasters, national school networks and ICT platform vendors)."

DSpace
http://www.dspace.org/
DSpace has been developed by MIT Libraries and Hewlett-Packard as a "digital institutional repository that captures, stores, indexes, preserves, and redistributes the intellectual output of a university's research faculty in digital formats". The system is "freely available to research institutions world-wide as an open source system that can be customized and extended." The initiative is now supported by the DSpace Federation.

FEDORA - Flexible Extensible Digital Object and Repository Architecture
http://www.fedora.info/
"An open-source digital object repository management system …[that] demonstrates how distributed digital library architecture [FEDORA] can be deployed using web-based technologies, including XML and Web services."

JORUM +
http://www.jorum.ac.uk/
"The JISC Online Repository for [Learning and Teaching] Materials (JORUM) will be a repository service for all Further and Higher Education Institutions in the United Kingdom (UK), providing access to materials and encouraging the sharing, re-use and re-purposing of them between teaching staff."

JSTOR – The Scholarly Journal Archive
http://www.jstor.org/
Supported by hundreds of commercial publishers and institutional partners JSTOR aims to provide portal access to a wide range of scholarly journals while also addressing preservation issues, ensuring their archival.

MERLOT – Multimedia Educational Resource for and Online Teaching
http://www.merlot.org/
A free, peer-reviewed collection of teaching and learning resources useful for higher education (US based).

The Learning Federation
http://www.thelearningfederation.edu.au/
A major 5-year (2001-2006) initiative aimed at developing online interactive curriculum content specifically for Australian and New Zealand schools that can be shared across all the k-12 systems via a Learning Object Exchange.

Further reading:
Interoperability between Library information Services and Learning environments – Bridging the Gaps
http://www.imsglobal.org/digitalrepositories/CNIandIMS_2004.pdf
N. McLean, & C. Lynch, (2004). *A Joint White Paper on behalf of the IMS Global learning Consortium and the Coalition for Networked Information.*

C. Peer-to-Peer (P2P)

Peer-to-peer (P2P) networks, while community-driven and designed around non-hierarchical or control-based architectures, also develop and depend upon standards and protocols. P2P networks generally function as cooperative (and often anonymous), distributed file-systems that enable applications such as file and resource sharing, instant messaging, gaming and auctions, and a wide variety of collaborative computing. Examples include Kazaa, GNUtella, FreeNet, JXTA, and MusicBrainz; applications useful for learning, education, and training include EduTella and LionShare.

EduTella
http://edutella.jxta.org/
A multi-staged effort to scope, specify, architect and implement an RDF-based metadata infrastructure for JXTA ("a set of open, generalized peer-to-peer protocols that allow any connected device (cell phone, to PDA, PC to server) on the network to communicate and collaborate").

LionShare
http://lionshare.its.psu.edu/
The LionShare P2P project aims "to facilitate legitimate file-sharing among individuals and educational institutions around the world. By using Peer to Peer (P2P) technology and incorporating features such as authentication, directory servers, and owner controlled sharing of files, LionShare promises secure file-sharing capabilities for the easy exchange of image collections, video archives, large data collections, and other types of academic information. In addition to authenticated file-sharing capabilities, the developing LionShare technology will also provide users with resources for organizing, storing, and retrieving digital files.

Currently, many academic digital collections remain "hidden" or difficult to access on the Internet. Through the use of LionShare technology, users will be able to find and access these information reservoirs in a more timely and direct manner -- employing one rather than multiple searches. LionShare will also provide users with tools to catalog and organize personal files for easier retrievals and enhanced sharing capabilities."

D. Educational Modelling Languages

Developed mostly within a European context a number of educational modelling languages have been defined since 1998. These languages have been designed to provide a holistic description of the *processes, interactions, and relationships* common to most 'learning environments'. As such, they are technology independent and clearly represent a distinct approach to pre-application modelling. Examples include PALO … but probably the most significant is EML (Educational Modelling Language) developed at the Open University of The Netherlands.

PALO
http://sensei.lsi.uned.es/palo/
"PALO is based on a reference framework to design educative content based in **5 levels of abstraction**. Each level identifies a certain group of related components or elements of a learning resource. The language allows to define teaching strategies by means of the definition of specific DTD's called ***instructional templates.*** These templates are a general type of PALO document that specially suits for a given instructional or teaching purpose.

PALO has been designed to be a **technology-independent representation of a learning resource,** thus allowing educative content interchange, interoperability, maintainability, and reusability. A PALO description of a learning content (a *.palo file) can be turned into a variety of learning scenarios (each one built using an specific delivery format) via a **compiling** process."

EML – Educational Modelling Language
http://eml.ou.nl/
In terms of adoption EML has been the most successful educational modelling language so far developed. It has provided the foundation for version 1.0 of the IMS Learning Design specification providing a framework for modelling pedagogical process and learning activities. A central concept to EML is a "unit of learning" and, more importantly, units of learning do not have to be content-driven. As such, EML can be used to specify interactions and activities that involve relationships between such entities as parties (with roles), content, learning designs, methods, learning objectives, prerequisites, properties, activities, environment, and services.

FLE3 – Future Learning Environment (Finland) – **an implementation of EML**
http://fle3.uiah.fi/
"Fle3 is a web-based learning environment. To be more specific Fle3 is Open Source server software for computer supported collaborative learning (CSCL) and released under the GNU General Public License (GPL). Fle3 is designed to support learner and group centered work that concentrates on creating and developing expressions of knowledge (i.e. knowledge artefacts) and design. Fle3 contains three learning tools and several administration tools and is easy to localize to different languages (all you need to do is to translate one file). Currently users may choose their user interfaces language to be Finnish, English, Spanish, French, Portuguese, Brazilian Portuguese, Norwegian, Dutch, Italian, Lithuanian, Estonian, German, Polish, Danish or Chinese."

TeachML – TargeTeam (TArgeted Reuse and GEnerations of TEAching Materials)
http://www.targeteam.net/
"TargeTeam is a system [developed by researchers in two German universities] for supporting the preparation, use, and reuse of teaching materials… and based upon TeachML."

TML – Tutorial Modelling Language
http://www.ilrt.bris.ac.uk/netquest/about/lang/
"Tutorial Markup Language (TML) is an interchange format designed to separate the semantic content of a question from its screen layout or formatting. The language is designed to support several different types of question within the same content model. TML 4.0 is essentially a super-set of HTML, with new elements added to describe question information. TML version 4.0 has been specified using SGML, an ISO standard language for formally describing document types. Future versions of TML are likely to be represented using Extensible Markup Language (XML), a

simplified subset of SGML, and be structured using the data modelling facilities of the Resource Description Framework (RDF). Work is currently in progress on TML version 5.0, re-named *Tutorial Modelling Language* to mark the shift to an RDF-based approach."

E. Learning Design

"Despite its relatively recent appearance in connection with e-learning, the concept of 'designing for learning' is far from being a new idea. … [However] the central ideas behind learning design represent new possibilities for increasing the quality and variety of teaching and learning within an e-learning context:

- The first general idea behind learning design is that people learn better when actively involved in doing something (i.e. are engaged in a *learning activity*).
- The second idea is that learning activities may be sequenced or otherwise structured carefully and deliberately in a *learning workflow* to promote more effective learning.
- The third idea is that it would be useful to be able to record 'learning designs' for sharing and re-use in the future."

(Sandy Britain, A Review of Learning Design: Concept, Specifications, and Tools, JISC, May 2004 http://www.jisc.ac.uk/uploaded_documents/ACF83C.doc)

CopperCore
http://coppercore.org/
Developed by the OUNL as "the IMS Learning Design Engine" CopperCore is a J2EE runtime engine designed to enable the inclusion of IMS Learning Designs into other applications.

Learning Activity Management System (LAMS)
http://www.lamsinternational.com/
"E-learning has a well developed approach to the creation and sequencing of content-based, single learner, self-paced learning objects. However, there is little understanding of how to effectively create and deliver sequences of learning activities which involve groups of learners interacting within a structured set of collaborative environments, or how teachers can make these sequences easily re-usable." This is what LAMS addresses. LAMS is now supported by The LAMS Foundation, a not-for-profit organisation committed to the principles of open source.

Learning Designs
http://www.learningdesigns.uow.edu.au
This web site has been designed for teachers and instructors in higher education to access a rich set of resources that support the development of flexibly delivered high quality learning experiences for students.

F. Virtual Reference

Digital Reference, or "AskA", services are Internet-based question-and-answer services that connect users with experts and subject expertise. Digital reference services use the Internet to connect *people* with *people* who can answer questions and support the development of skills." (Virtual Reference Desk)

AskNow!
http://www.asknow.gov.au/
Australia's first collaborative reference service involving participation from National, State and Territory libraries in Australia.

DREI - Digital Reference Education Initiative
http://drei.syr.edu/
"The Digital Reference Education Initiative (DREI) seeks to bring together the collective expertise of practitioners, library educators, and digital reference software developers interested in issues of education and training in order to develop core competencies, and educational approaches to digital reference. DREI's main goal is to create an adaptable collection of core competencies, standards, tools, and training materials that may be used in various library and other information industry settings, and to provide access to these materials through this site."

NISO Networked Reference Services (z39.90-200x)
http://www.niso.org/standards/dsftu.html
A draft NISO standard also referred to as Question/Answer Transaction Protocol, QATP, for trial use and comment until April 2005. "Digital reference services constitute a new but rapidly growing extension of the traditional reference service offered to library patrons. While the service may be delivered via real-time chat or asynchronous e-mail, the essential characteristic of the service is the ability of the patron to submit questions and to receive answers via electronic means."

Questionpoint
http://www.oclc.org/questionpoint/default.htm
"QuestionPoint is a unique virtual reference service, supported by global network of cooperating libraries worldwide, as well as an infrastructure of software tools and communications. … Cooperation and collaboration are the keys to QuestionPoint's power and success. OCLC is a proven leader of library cooperation, and the Library of Congress provides the largest reference service in the world. Combined, [with the other member libraries] the result is the worldwide cooperative reference service."

VRD – Virtual Reference Desk
http://www.vrd.org
"The Virtual Reference Desk (VRD) is a project dedicated to the advancement of digital reference and the successful creation and operation of human-mediated, Internet-based information services. VRD is sponsored by the United States Department of Education.

G. Search

Resource discovery and information retrieval are not only key components of e-learning infrastructure but they continue to be the focus of widespread R&D.

EduSource Common Language (ECL)
http://www.edusplash.net/technical/ecl/index.html
A web services binding of the IMS DRI federated search specification.

Simple Query Interface (SQI)
http://nm.wu-wien.ac.at/e-learning/interoperability/sqi/sqi.pdf

An initiative partly sponsored by the CEN/ISSS Workshop on Learning Technologies with contributions from ARIADNE, EducaNext, Celebrate, Edutella, Elena, EduSource, ProLearn, Universal, and Zing. The paper is focused on an API for querying learning object repositories.

Z39.50 Specifications
http://www.loc.gov/z3950/agency/
This has been the basic standard for libraries worldwide for over the last decade.

SRW – Search/Retrieve Web Service
http://lcweb.loc.gov/z3950/agency/zing/srw/
"SRW defines a web service for searching databases containing metadata and objects, both text and non-text. The SRW Initiative builds on Z39.50 along with web technologies. Building on Z39.50 semantics enables the creation of gateways to existing Z39.50 systems; web technologies reduce the barriers to new information providers allowing them to make their resources available via a standard search and retrieve service."

Distributed Search Manager
http://search.edna.edu.au
education.au limited has developed an open source federated searching tool that can be configured to search across designated repositories.

Google 4 Education
http://chronicle.com/free/2004/04/2004040901n.htm
Google has teamed up with the MIT and 16 other universities around the world to provide a way to search institutional collections of scholarly papers.

MERLOT Federated Search
http://fedsearch.merlot.org/
Early stages but providing access to aggregated search results across MERLOT, SMETE, and EdNA Online.

NISO MetaSearch Initiative
http://www.niso.org/committees/MetaSearch-info.html
"Metasearch, parallel search, federated search, broadcast search, cross-database search, search portal have become commonplace in the information community's vocabulary. They speak to a common theme of allowing search and retrieval to span multiple databases, sources, platforms, protocols, and vendors at once. …Metasearch services rely on a variety of approaches to search and retrieval including open standards (such as NISO's Z39.50), proprietary API's, and screen scraping. However, the absence of widely supported standards, best practices, and tools makes the metasearch environment less efficient for the system provider, the content provider, and ultimately the end-user. To move toward industry solutions NISO is sponsoring a Metasearch Initiative to enable:

- metasearch service providers to offer more effective and responsive services
- content providers to deliver enhanced content and protect their intellectual property
- libraries to deliver services that distinguish their services from Google and other free web services."

RDN – Resource Discovery Network
http://www.rdn.ac.uk
"The RDN is a collaboration of over seventy educational and research organisations, including the Natural History Museum and the British Library. In contrast to search engines, the RDN gathers resources which are carefully selected, indexed and described by specialists in our partner institutions. You can be confident that your search results and browsing will connect you to Web sites relevant to learning, teaching and research."

Enhancing the RDN are two key services:

- The Virtual Training Suite, a service aimed at educating users about techniques for discovering subject-specific resources on the Internet; and
- RDN Include – allowing users to include the RDN search service, *ResourceFinder*, on their own websites.

H. Publishing

Clearly, the Web has triggered major changes within the publishing industry. Traditional supply and distribution chains are being transformed, value-added and creator-to-consumer services being created, and blogging has redefined 'self-publishing'.

Common Ground
http://commongroundgroup.com/Publishing/
Publisher specializing in the production and management of content for print and the Internet.

McGraw-Hill – PageOut
http://www.pageout.net/
A free Course Management System that enables easy assembly of digital content as teaching materials via a series of templates.

McGraw-Hill Higher Education eLearning Group
http://www.mhhe.com/elearning/
A new e-learning Division of McGraw Hill Higher Education launched in June 2004.

Thomson Learning – TextChoice
http://www.textchoice2.com/broker.jsp
A value-added service that provides easy access to digital content from which teachers can create custom learning materials.

The educated blogger: Using weblogs to promote literacy in the classroom
http://firstmonday.org/issues/issue9_6/huffaker/index.html
D. Huffaker, *First Monday,* volume 9, number 6 (June 2004).

I. Mobile Learning

From Issue 5 of the *MOBIlearn Newsletter*: "Some forecasters estimate that there will be almost a 100 million mobile users in Africa by 2005. … we can therefore differentiate between two ideal target markets for m-learning. One is learners that are either without infrastructure and access - third world rural or remote area learners who have mobile phones. The other group are learners that are continually on the move - first world learners who are the workforce on the move with state of the art mobile devices."
http://www.mobilearn.org/download/press/Mobilearn%20Newsletter%205.pdf

E-Learning Infrastructure for Mobile Virtual University
http://www.mine.tku.edu.tw/NSC-NRC5/Project.htm
Canada (NRC-IIT) & Taiwan (National Sciences Council & Tamkang University) are collaborating on researching *e-Learning Infrastructure for Mobile Virtual University*, a three-year project commenced in April 2002. The project aims to research and develop an infrastructure to support mobile and distributed e-learning that provides security, privacy, authentication, mobile identity management and new communication tools for cooperative and interactive learning.

MOBIlearn
http://www.mobilearn.org/
"MOBIlearn is a worldwide European-led research and development project exploring context-sensitive approaches to informal, problem-based and workplace learning by using key advances in mobile technologies.

The MOBIlearn project consortium involves 24 partners from Europe, Israel, Switzerland, USA and Australia. Their competencies are integrated and extended by a Special Interest Group which includes 250 of the world's leading organisations, active in Information Technology.

The project addresses most of the key objectives of the Multimedia content and tools area of FP5 IST programme and it is strategically positioned to provide relevant research outcomes for the FP6."

J. Games for Learning, Education, and Training

Marc Prensky makes some important observations: "Despite a large number of products out there, I would argue that none of the educational software we really need has been built yet. What we have built, however, are a large number of good bits and pieces, scattered about in hundreds of different software offerings. Almost every product contains a few good (or great) gems of ideas among a lot of so-so (or terrible) stuff. … Among the products we need to look at, are edutainment software, education software, health and medical software, socially oriented software, corporate and military applications, and, increasingly, offerings from the games world. Each of these individual products has solved some tiny piece of the education software puzzle extraordinarily well. If we could just combine all the very best features of every vendor's products right now, we would no doubt have something relatively decent to start out from." (http://www.marcprensky.com/writing/)

Games2Train
http://www.games2train.com/
Another Prensky site that aims to "marry the fun of playing a videogame or computer game together with all the information needed to accomplish training objectives."

Social Impact Games
http://www.socialimpactgames.com/
Initiated by Marc Prensky this site has been established for "projects, information, and people in a single place and to be a catalyst for ideas and innovation in spreading the wider uses of games as a language for more than just entertainment."

Training Superiority (DARWARS)
http://www.darpa.mil/dso/thrust/biosci/training_super.htm
"The Training Superiority Program seeks to transform military training by providing continuously-available, on-demand mission-level training for all forces at all echelons. This goal will be attained by providing a new kind of cognitive training experience for units and individuals based on continuously available wars.
(see also Department of Defense Game Developers' Community for other resources on defense gaming: http://www.dodgamecommunity.com)

K. Next Generation Internet

CANARIE (Canada)
http://www.canarie.ca/
"CANARIE's mission is to accelerate Canada's advanced Internet development and use by facilitating the widespread adoption of faster, more efficient networks and by enabling the next generation of advanced products, applications and services to run on them."

DANTE (Europe)
http://www.dante.net/
"DANTE's purpose is to plan, build and operate pan-European networks for research and education. DANTE (Delivery of Advanced Network Technology to Europe) has been fundamental to the success of European research networking over the last decade. Owned by European NRENs (National Research and Education Networks), and working in partnership with them and in cooperation with the European Commission, it provides the data communications infrastructure essential to the success of many research projects in Europe today."

GrangeNet (Australia)
http://www.grangenet.net/
Grid **a**nd **n**ext **ge**neration **Net**work was established in 2003 with a three-year plan in which to develop and operate high bandwidth grid and advanced communications services for the Australian higher education sector.

Internet2 (US+)
http://www.internet2.edu

Primarily a US consortium of academia and industry focused on developing and deploying next generation Internet technologies.

SuperJANET (UK)
http://www.ja.net/SJ5/index.html
Builds on the foundations established through JANET (UK's Joint Academic research Network) but focused on broadband services.

Further information resources available from:
Global Next Generation Internet Initiatives, Prasanna Kumar Jagannathan http://www.cse.ohio-state.edu/~jain/cis788-99/ftp/testbeds/

The Educational Semantic Web, Anderson and Whitelock, *Journal of Interactive Media in Education*, 2004 (1), Special Issue on the Educational Semantic Web.
http://www-jime.open.ac.uk/2004/1

L. Regional Initiatives

AFRICA

SchoolNet Africa – African Education Knowledge Warehouse (AEKW)
http://www.schoolnetafrica.net/
The African Education Knowledge Warehouse (AEKW) is a multi-lingual (Arabic, English, French, Kiswahili, Portuguese) pan-African portal aimed at servicing SchoolNet Africa practitioners, policymakers and school-based communities focused on ICTs in education across Africa.

African Virtual University
http://www.avu.org/
Initiated in 1997 and headquartered in Nairobi it is currently aiming to expand its service to 150 learning centres by 2007 throughout 50 African countries. It utilizes both Internet and satellite technologies.

ASIA

Asian E-Learning Network (AEN)
http://www.asia-elearning.net/index.html
AEN has a threefold mission:
- Share information on the latest e-Learning trends and technologies
- Promote interoperability and resource sharing of e-Learning systems and contents
- Promote the spread of knowledge on the effective use of e-Learning.

Current membership includes Brunei, Cambodia, Japan, Korea, Lao P.D.R., Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam.

AUSTRALIA

AEShareNet
http://www.aesharenet.com.au/
AEShareNet facilitates the trading of licenses for learning materials. This includes a full end-to-end service: the discovery of learning/training materials, negotiation of a license, and payment. In May 2004 AEShareNet also launched a custom license known as "FfE" (Free for Education).

EdNA Online
http://www.edna.edu.au/
Launched in 1997, it is both a portal and a repository of information and services with a mission to support and promote the benefits of the Internet for learning, education and training in Australia. Through a range of XML APIs some of its services or functionality can be integrated into stakeholder websites.

K-12 Learning Architectures
http://icttaskforce.edna.edu.au/documents/learning_architecture.pdf
http://icttaskforce.edna.edu.au/documents/inter/system_architecture.pdf

myFuture
http://www.myfuture.edu.au/
Australia's online career information service that assists users in making career decisions and managing work transitions. *MyFuture* includes a personalized planning tool, *My Guide*, and detailed information about occupations, industries, funding sources, grants and scholarships, detailed regional information and much more.

CANADA

EduSource
http://www.edusource.ca/
(DLORN) July 2002 – December 2003
Aimed at developing a Pan-Canadian directory of linked and interoperable learning object repositories. Based on current international specs & standards.

CHINA

Chinese e-Learning Technology Standardization Committee
http://www.celtsc.edu.cn/
http://media.cs.tsinghua.edu.cn/~pervasive/projects/e-learning/index.html

Connecting All Schools
http://www.edu.cn/HomePage/english/index.shtml
In 2000, China's Ministry of Education launched the "Connecting All Schools" project. It aims "to equip 90% of schools with intranet and education management systems in 5 to 10 years' time, enabling teachers and students in primary and secondary schools to share and use online education resources."

EUROPE

EducaNext Portal for Learning Resources
http://www.educanext.org/ubp
Powered by the "Universal Brokerage Platform" EducaNext is both a portal and an exchange aimed at servicing higher education in Europe. It provides access to collaboration with peers while also providing catalogues of resources (content and activities) that are either free or for a fee.

eLearning Europa
http://elearningeuropa.info/
An initiative of the European Commission initiative eLearning Europa serves as a portal for information about Internet-enabled education, training and lifelong learning. It highlights key themes and issues, such as: new learning processes and educational use of technology: search strategies; requirements of new EC Members; Special Needs; Personalised Instructional Design; Paradigms of ICT & Education; Language Learning; Digital Libraries; e-learning Evaluation; and the Digital Divide.

eLearning Initiative (Europe)
http://europa.eu.int/comm/education/elearning/
"The eLearning Initiative aims to enhance the use of new multimedia technologies and the Internet to improve the quality of learning by facilitating access to resources and services as well as remote exchanges and collaboration."

European Schoolnet
http://www.eun.org/portal/index-en.cfm
"The European Schoolnet is a unique international partnership of 26 Ministries of Education developing learning for schools, teachers and pupils across Europe and beyond. We provide insight into the use of ICT (information and communications technology) in Europe for policy-makers and education professionals. This goal is achieved through communication and information exchange at all levels of school education using innovative technologies and by acting as a gateway to national and regional school networks".

IRELAND

Skoool.ie Interactive Learning
http://www.skoool.ie/
More than a portal, skoool.ie provides free access to K-12 curriculum materials for Irish students. It is a collaboration between AIB Bank, The Irish Times, and Intel Ireland in association with other leading corporate supporters.

JAPAN

Advanced Learning Infrastructure Consortium
http://www.alic.gr.jp/eng/
Consortium of Japanese e-learning stakeholders primarily comprises of industry players (e-learning software developers and content providers) and academic partners (primarily universities). It aims to "reasonably and effectively provide learning environment which enables anyone to learn anytime and anywhere, according to the goals, pace, interests, understanding of individuals and groups."

eLC - e-Learning Consortium (Japan)
http://www.elc.or.jp/english.htm
Somewhat narrower in scope than ALIC, the eLC is primarily focused on e-learning standards development and adoption.

KOREA

EduNet

http://www.edunet4u.net/edunetWebApp/jsp/english/introduction.jsp

A comprehensive information service and portal aimed at supporting a lifelong learning network in Korea.

MALAYSIA

Malaysian Grid for Learning

http://www.lgfl.net/mygfl/

http://www.mygfl.net.my/

(to be launched in July 2004). A government-sponsored initiative that will provide access to both free and commercial materials useful for teaching and learning.

UNITAR e-learning Community

http://elc.unitar.edu.my/index.php

A comprehensive portal on e-learning developed by the Malaysian Open University (Universti Tun Abdul Razar) facilitating open knowledge sharing and providing access to a wide range of resources including learning object repositories and listings of useful blogs worldwide.

MEXICO

http://oats.harvestroad.com.au/hive/quickfetch.html?VIEWTYPE=Original&IDTYPE=Alias&ID=876

Instituto Latinoamericano de la Comunicación Educativa (ILCE) – vision is "to create an eLearning platform that established a repository of content from education and government sectors that could be repurposed by course developers according to need. … During the solution development phase ILCE moved from the initial question upon which most organisations focus, "Which Learning Management System (LMS) should I buy?" to a much deeper understanding of how an holistic eLearning strategy can provide efficiency, economies of scale, sharable content and the ability to create competency-driven learning scenarios. When you explore the situation in depth like this, the emphasis quickly shifts away from the LMS to the independent digital repository as the most important application."

NORWAY

e-Standard Project

http://www.estandard.no/om_prosjektet/index_eng.html

The Norwegian Educational Technology Interoperability Project (E-standard Project) is part of the Ministry of Education and Research's initiative to establish a **National Learning Network** and a **National web portal for education**. It is funded by the Ministry of Education as part of the Programme for Digital Competence (2004 – 2008).

PHILIPPINES

ITECC ePhilippines

http://www.itecc.gov.ph/ephilippines.htm

"An electronically enabled society where the citizens live in an environment that will encourage and promote the access to technologies providing quality education, efficient government service, greater sources of livelihood, and, ultimately, a better way of life"

SINGAPORE

Singapore e-Learning Competency Center

http://www.ecc.org.sg/

Launched in 2001 following a series of related government-supported projects the ECC now provides a range of services to the e-learning community in Singapore (vendors and consumers) such as courseware evaluation. It builds on a strong advocacy for e-learning standards adoption and development and also functions as a portal to a range of e-learning products and services.

THAILAND

NECTEC, UniNet e-learning Consortium

http://www.nectec.or.th/english/

"A research and development organization in electronic, computing, telecommunication and information technologies (ECTI) for strengthening the sustainable economy and knowledge-based society."

UK

BBC Learning

http://www.bbc.co.uk/learning/index.shtml

"The combination of a variety of platforms gives access to a greater range of learners. The BBC is developing an interesting strategy on e-learning to reach sections of the population who are resistant to more formal learning approaches. Public service broadcasting has always had a role in learning. A responsibility to provide educational programmes has been written into the BBC's successive Royal Charters from the 1920s onwards. However, as the technology has evolved, so too has the ability to meet this responsibility in new ways, offering different approaches to learning and new means of reaching learners."
(Wendy Jones, Head of Public Affairs & Policy, BBC Learning)

British Education Index

http://www.leeds.ac.uk/bei/

Designed as a portal service providing easy access to information services relevant to the work of researchers, policy makers and practitioners in the fields of education and training.

Curriculum Online

http://www.curriculumonline.gov.uk/

Curriculum Online is central to the UK Government's drive to "transform teaching and learning in schools by improving access to ICT and multimedia resources for all pupils."

National Grid for Learning Scotland (NGfL Scotland)

http://www.ltscotland.org.uk/ngflscotland/

NGfL Scotland was established in 1999 to "to secure the benefits of advanced networked information technologies for all sectors of education and lifelong learning". Aims to service a broad constituency (practitioners, managers, local authorities, parents and others involved in or concerned with Scottish education) across three main areas: **infrastructure, content, and professional development.** "There has been significant investment in the production and licensing of online resources including the licensing of SCRAN

for all Scottish schools. Through public procurement, a framework of companies has been established able to provide digital content in support of learning."

RDN/LTSN Partnership
http://www.ariadne.ac.uk/issue39/powell/
JISC funded activity focused on learning resource discovery based on the LOM and the OAI-PMH

SCRAN
http://www.scran.ac.uk/
A learning image website providing "access to quality images, sounds, movies and learning resources. There are over 300,000 images from museums, galleries and archives. In addition, there are learning packs such as pathfinders, resources, topics and curriculum navigator."

USA

GEM – Gateway to Educational Materials
http://www.thegateway.org/
Established in 1997 and funded by the US Department of Education through the ERIC Clearinghouse on Information & Technology GEM serves as a gateway to learning resources that would be of interest to teachers (such as lesson plans and curriculum units). Significantly, it was a leader in education-focused metadata schema (based on Dublin Core).

In early 2004 GEM was re-engineered and has integrated "an advanced retrieval engine named Seamark from Siderean … built around a search technique called "faceted searching". Faceted searching combines searching for specific words and phrases with browsing descriptions of resources - based on what are called facets."

21st Century Learning Infrastructure Project (State-based example)
http://www.infoweb.state.ia.us/21/
State of Iowa – "This modern learning infrastructure enables hospitals, state and federal government, public defense armories, libraries, K–12 schools and higher education communication via two-way, high-quality, full motion video and audio conferencing, high-speed Internet connections, and standard telephony."

MIT Open Courseware
http://ocw.mit.edu/index.html
"A free and open educational resource for faculty, students, and self-learners around the world. OCW supports MIT's mission to advance knowledge and education, and serve the world in the 21st century.
MIT OCW:

- Is a publication of MIT course materials
- Does not require any registration
- Is not a degree-granting or certificate-granting activity
- Does not provide access to MIT faculty"

OpenVES
http://openves.org/
"Our mission is to help create standards, to provide a reference implementation of an open architecture, public, standards based PK12 eLearning platform, and to use those standards, and that platform to help teachers and students transform PK12 education, one classroom at a time. We will work with others engaged in this work who are developing technologies (specifications, guidelines, software, and tools) that help create a forum for information exchange, a new digital marketspace for edcommerce, inspiration, independent thought, and collective understanding."

Scout Portal Toolkit
http://scout.wisc.edu/Projects/SPT/
The Scout Portal Toolkit provides a low-cost solution in facilitating the sharing of repository resources.

US Open e-Learning Consortium (USOeC)
http://marlin.ctlt.org/projects/us_open_e_learning/
"The US Open e-Learning Consortium exists to accelerate the deployment of statewide, interoperable, e-learning and decision-support platforms by documenting consensus among a critical mass of states for a common high-level design and aligning state and national resources around that design." Also promotes the adoption of e-learning technical specifications and standards.

Further regional information available from:
Global Gateways – A Guide to Online Knowledge Networks
http://www.educationau.edu.au/research/global_gateways_v3.pdf

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M. Other Initiatives

AccessNSDL
http://accessnsdl.org
"The (US) National Science, Technology, Engineering, and Mathematics Education Digital Library (NSDL) holds enormous promise to enrich the interest and understanding of learners of all ages as they pursue education or careers in science, technology, engineering or mathematics (STEM). However, very little of this enriched and supported STEM content will be meaningful to learners, parents, teachers, researchers or trainers with disabilities without a concerted effort to infuse access considerations into the priorities, practices and policies of the NSDL community.
The Access NSDL project will build the capacity of the NSDL to meet the needs of users with disabilities."

ACLS- American Council of Learned Societies Cyberinfrastructure Project
http://www.acls.org/cyberinfrastructure/cyber.htm
"the ACLS has appointed a national commission on cyberinfrastructure in the humanities and social sciences. This commission will carry out research, hearings, and consultations to gather information and develop perspective, completing its work within the calendar year 2004 and issuing its report in early 2005. The intended

audience for that report includes the scholarly community and the societies that represent it, university provosts, federal funding agencies (including but not limited to the NSF), and private foundations."

AllLearn (Alliance for LifeLong Learning)
http://www.alllearn.org/
Servicing a niche market, "an online learning consortium among Oxford, Stanford, and Yale universities formed in September 2000 to provide the highest quality, college level online courses and educational offerings … Programs combine elements of taking classes in person with the advantages of learning at your home or office. Our programs offer online access to an instructor and encourage interaction with fellow students while accommodating the busy schedules of our students."

Java Education and Learning Community (JELC)
http://community.java.net/edu-jelc/
"a gathering place for Java-related researchers and educators: teachers, academics, researchers, programmers, authors, corporate trainers, administrators, public officials, students and others."

Medbiquitous
http://www.medbiq.org/about_us/mission/index.html
"Founded by Johns Hopkins Medicine and leading professional medical societies, MedBiquitous is an international group of professional medical associations, universities, commercial, and governmental organizations dedicated to advancing medical education through technology standards that promote professional competence, collaboration, and better patient care … MedBiquitous members are creating a **technology blueprint for professional medical education**. Based on XML and Web services standards, this blueprint will weave together the many activities, organizations, and resources that support the ongoing education and performance of clinicians, creating more integrated access to educational resources, scientific journals, pharmaceutical and device product information, and clinical trials and registries. Ultimately, this blueprint will seamlessly support the medical learner in ways that will improve patient care and simplify the administrative work associated with education and competence assessment."

Service Oriented Architectures
For definition and links to other sites see:
http://www.webopedia.com/TERM/S/Service_Oriented_Architecture.html
http://www.eweek.com/category2/0,1738,1571000,00.asp

The Web Services Interoperability Organization
http://www.ws-i.org
"is an open industry effort chartered to promote Web Services interoperability across platforms, applications, and programming languages. The organization brings together a diverse community of Web services leaders to respond to customer needs by providing guidance, recommended practices, and supporting resources for developing interoperable Web services."

UNESCO ICT Portal for Teacher Training
http://www.unescobkk.org/ips/ict/ict.htm
Comprehensive portal to resources for teacher training in information and communications technologies. Part of UNESCO's Asia-Pacific Programme on ICT in Education.