The Knowledge Exchange Testbed

Stage 1 Research Report– System Testing and Configuration

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Content

Project background

In November 2004, The Institute for Working Futures Pty. Ltd. as a member of the UNITAS Knowledge Centre instigated a major international project to:

> *provide a testbed to showcase third–generation open standards technologies capable of spanning an end-to-end, knowledge and learning object management supply chain. (Bowles, September , 2004:1)*

The testbed was established to run from January 2005 to March 2006. The project was privately funded. Nevertheless, all activity was at all times to be vendor neutral and to adopt an open standards approach, so that at any time key partners could 'mix and match' technology or content deployed in the overall solution being researched.

The ability to 'mix and match' technology in Stage 1 was duly considered from a 'functional' perspective and the considerations of the stakeholders and vendors was considered in line with their reputations. All vendors were Australian-based, possessing robust commercial reputations in the global marketplace.

The testbed also sought to examine the commercial and technical realities of an e-learning supply chain that encompassed not just open standards but also Service Oriented Architecture (SOA). As an architectural style, SOA focuses on the customers and end users of the service shaping requirements and interoperation of component applications. In an SOA environment, nodes on a network make resources available to other participants in the network as independent services that the participants access in a standardised way[✪]. This is a distinct departure from traditional object oriented architectures where data and functionality are tightly bound together in application services. The paradigm of SOA over traditional object oriented approaches may be highlighted by the example you do not buy a new computer to

[✪] http://en.wikipedia.org/wiki/Service_Oriented_Architecture and see http://www.service-architecture.com/web-services/articles/service-oriented_architecture_soa_definition.html

run a new application or to process data for a new application, so why embed e-learning content and applications in only one set of e-learning technologies?

As complexity of IT and networks increases, businesses have recognised the need to adopt architectures that enable maintenance, development and adaptation to new requirements. For business, customer-oriented systems is nothing new. Lose focus on the customer, and you lose business competitiveness. SOA allow businesses to evolve technology and systems they have acquired to dynamically respond to emerging customer imperatives. SOA also enhances how businesses can manage complex IT systems; achieve integration across multiple interfaces and different programmes; and still achieve not only technology but process integration consistent with core business requirements.

The testbed was to graduate from research activities in March 2005, to undertake development and refinement of the model from March 2005 to March 2006. Stage 1 of the testbed concentrated on bedding down of the systems and processes, and Stage 2 the further development of applications and new practices relating to the refined end-to-end, knowledge and learning electronic supply chain. Stage 2 also represented the commercialisation of the overall model and testing by commercial entities of the technology and processes.

This report represents the completion of Stage 1 of the testbed. It is three months late. The time delay in completion of the research stage represents not only the problems encountered, but the major findings addressed and the more complex nature of the issues tackled in Stage 1. This was especially so for the issues associated with interfacing Learning Management Systems (LMS), Learning Object Repositories (LOR), authoring tools, and e-commerce applications.

This report is not intended to report on the management or funding aspects of the testbed. The report is focussed on the applied findings and the implications of these findings for Stage 2 of the testbed. Critically, Stage 1 has laid the foundations for not only justifying continuation to Stage 2, it has formed the basis for more significant development effort to achieve the completion of the testbed in March 2006.

A web site has been established to overview the research and development of the testbed. It can be accessed at http://www.marcbowles.com/tke/about.htm.

Action research

There are eight (8) major themes associated with research undertaken on the testbed. Individually these projects have their own research methodologies and approaches.

It is important to note that all research has leveraged off the major projects that had been undertaken by the UNITAS Knowledge Centre (UKC). The UKC is a collaborative body (co-laboratory) founded by the Commonwealth Bank of Australia and the University of Tasmania and the State Government of Tasmania in 2002. It provides collaborative framework and infrastructure for leading private organizations to research, test and advance the implementation of learning and knowledge. A number of research partners also joined with the UKC to complete in 2003-2004 a major international Learning to E-learn research project that resulted in complete re-evaluation of e-learning practices in corporate and community settings. The research was published in case studies, a research report and an e-learning process manual (http://www.portal.unitas.com.au/elearn/elearnindex.asp). The non-commercially sensitive research and findings were also published in a book, Bowles, M (2004) *Relearning to E-learn* (http://www.mup.unimelb.edu.au/ebooks/0-522-85130-4/). Interestingly this was the first publication in Australia to follow a tri-publication process (hardcopy d-book, e-book, and online).

The research foundations have distinctly shaped each project in the testbed. However, all projects share a common research theme in the sense that they are focussed on applied

outcomes. Therefore the Stage 1 effort has concentrated on using the pure and applied research that shaped the projects to develop action research outcomes.

Action research is actively used in this project. Action research is promoted as the best form of research when the aim is to both encourage ownership and ensure the process of research and planning generates a sustainable result. Action research, as used by Dr Bowles and his team, involves the subjects of the research in the development and outcomes of the project in a spiralling set of steps that integrate action and research into one process. Team members have evolved their approach from the theoretical approach promoted by Kemmis and Grundy (1997), Burns (1994), Reason and Bradbury (2001), and Australian action research resources such as those listed by Southern Cross University online at http://www.scu.edu.au/schools/gcm/ar/arhome.html.

Action research is an appropriate vehicle to achieve the outcomes of this project, as it has the capacity to find not only the issues impacting individuals in their specific context, it can also incorporate the influence of contextual features in the process of the research. It has the assumption that such involvement is inevitable in any case, and that research should have the aim of improving the situation of the participants.

When managed by those familiar with the principle of 'spiralling improvement', action research can build and test processes and systems, while securing collaborative involvement in the planning, implementation and evaluative of each project. More importantly the methodology can permit different motivators and causal factors to be isolated and compared between different projects or participant groups.

Action research also serves to ensure the Stage 2 activities develop solutions (technical or new practices) that address research findings in Stage 1. Consistent with the central tenet of action research, case studies will not just be reporting what is occurring. They will be used to investigate and report practices and problems. The research will therefore be able to build a comparative framework for analysis and action that will achieve improvements to both practice and systems. (Avison, *et al.* 1999, p. 96)

The uniqueness of our team's approach is that Dr Bowles has been a leader in the use of action research as a basis to build and sustain learning and HR practice since the early 1990s. Some of these previous action research projects span players involved in this project; E.g. registered training organisations (RTOs), employers, regional organisations, commercial users of information and communication technology and government bodies.

Steering group - Expert Analysis

Throughout the testbed project expert analysis and input has been sought from a select panel. All members are experts in their respective fields of endeavour.

Table 1 Expert analysis group

Name	Expertise	Current position	Organisation
Dr Marcus Bowles	Learning and knowledge transfer and electronic distribution systems	Director	Working Futures®
Adam Maxwell	Design of accessible, mobile and usable content and delivery platforms	Managing Director	Aptitude Media
Sean Howell	Software engineering and programming	Managing Director	Intelitec Pacific P/L
Phill Bevan	Training delivery and QA	Managing Director	Esset Australia
Tim Lamberton	Web programming	Technical manager	UXels
Clive Bowles	Commercialisation and marketing	Managing Director	UXels

Case Studies

Action research is best achieved when findings are consolidated and comparative analysis conducted by individuals accessing research or writing on outcomes that are derived from a range of contexts. Case studies will be completed on all major aspects of the testbed. Case studies will not be extensive in terms of written analysis. Rather, they will be structured to set headings and intended to convey succinct information on each topic within a 3-5 page maximum limit (See Attachment 1).

The following table outlines where case studies will occur and, thence, analysis completed by the project manager in consultation with those involved.

Table 2 Project case studies

Case studies	Educational organisations involved	Organisations involved	Number of Case Studies
Stage 1 – Research on e-learning technology and the supply chain			
1. Streamlined workflows for instructional design and content authoring or reuse	Australian Maritime College, UTAS Knowledge Centre, Esset Australia	Working Futures, Aptitude Media	1
2. Promoting accessibility and personalisation of e-learning: Making the Diploma of Business (Frontline Management) fully accessible and mobile-ready	Esset, Australian Training Management, Others	Working Futures, Aptitude Media	1
3. Making learning strategic: Positioning the Diploma of Training and Assessment to build the national capability of providers and industries	Esset Australia, Australian Training Management (ATM), TAFE Tasmania, others	Working Futures, UXels, Aptitude Media	1
4. Laying the foundations for learner engagement: The role of a fully online Certificate III in Multimedia	Nil	John Andrius, Aptitude Media	1
5. Liberating assessment objects from a paradigm embedding them into learning objects and LMS systems: The QTI Creator™ and QTI Player™	Esset, ATM, TAFE Tasmania, others	Working Futures, Intelitec Pacific, Aptitude Media, eTechgroup, Harvest Road	1
Stage 2 – Development of applications and practices			
6. Integrating system QA for e-learning systems and the AQTF	Esset Australia	Working Futures	1
7. Automating the conversion of legacy content to standard compliant SCORM®, IMS or IMS QTI format: The Redoit™ packager and converter	Nil	Intelitec Pacific	1
8. Automating and integration learning object metadata approaches	Nil	Working Futures, Intelitec Pacific	1
9. Delivering e-learning in a mobile context: Developing and using a QTI mPlayer™	Esset, ATM, TAFE Tasmania, CBA, others	Working Futures, Intelitec Pacific, Aptitude Media	10+
10. Creating a B2B learning and assessment object exchange for the commercial sector	Nil	UXels, Working Futures	1
11. Re-evaluating the real ROI on e-learning	Nil	UXels, Working Futures	1

Findings: A snap shot of Stage 1 case studies

The following findings have been grouped under specific headings. The headings represent themes being investigated in the testbed. The individual case studies are slated for publication and placement on the research web site in August 2005.

Workflow Analysis

Research on workflows relating to the authoring, storage, assembly, delivery and reporting relating to e-learning using the testbed has illustrated the following:

- Somewhat counter intuitively to educational institutions, value creation in a business setting actually increases proportionally to how we enable the LMS to play a virtual role, not a controlling role, in the e-learning supply chain;
- Integration and management across learning technologies and between the learning supply chain and other enterprise systems is desirable and can best be done through an overall 'service layer';
- As data carries its own metadata on packaging, sequencing and overall delivery — a 'book end' supply chain process — is emerging whereby the Learning Object Repositories (LOR) reside at one end (knowledge an entity can control) and assessment resides at the other end (confirms knowledge transfer and utility);
- The supply chain is two-way with content or objects flowing down the channel and data on results and reporting flowing up the channel. It is therefore as important to integrate data management and reporting across the whole supply chain and it has become to integrate the management of content and objects through such technologies as the LOR. Advantage seems to also extend where neither are locked into a relationship with one LMS; and
- The organisations' investment and ROI is not in training and reuse of learning objects, it is in managing and valuing digital objects and then reporting their use. This enables the multiplier of reporting both human and knowledge capital value while as a parallel exercise actually confirming the increased value enterprise data has when tied to a purpose (i.e. Dynamic audit). Workflows that concentrate on learning and content miss the knowledge capital value of these activities. This has implications for the investment in learning technologies and the way in which such systems are designed.

Issues for exploration in Stage 2 include:

- Developing a vocabulary for LOM that deals with competencies/capabilities.
- Better streamlining of how assembly and authoring can automatically be completed by authors **not** familiar with or accessing LORs or LMS.
- Establishing a design for a database that can capture assessment and learning outcomes data and report it into LMS, LOR and enterprises databases such as relate to HR, KM, CRM, ERP and such like functions (i.e. Use of IMS Enterprise and LIP specifications).
- Establishing a means to more simply integrate the editing and labelling of objects packaged into standard compliant formats (i.e. SCORM, IMS, IMS QTI or any other such regime derived from or based on IEEE's Learning Object Metadata model).

Open Standards

The argument for moving towards open standards in e-learning technologies is convincing and pervasive. The testbed has shown convincingly the ability to work with open standards systems has enabled:

- Accelerated development of data transfer between systems.
- Improved capacity to integrate technologies.
- Open Knowledge initiative (OKI) principles and practices can apply.
- Service oriented architecture reinforces the move away from standardising learning technologies.

It is worth noting one of the assumptions that was seriously challenged with regards open systems was the expected ability to integrate different platforms. It was expected that the

integration of the LMS and LOR would be enabled greatly if both vendors adopted and embedded open standards philosophy into their systems. In the case of the integration of Fourpoint™ Learning Delivery System (LDS) from eTechgroup and the Hive® LOR from Harvest Road, the one month exercise to build an interface between these systems actually took 4 months. This was due to difficulty in aligning different vendor's development pathways and related priorities.

Open standards versus open source from the enterprise perspective
Open source has gained many success stories in global IT. For instance, the adoption of Linux® and Apache®. Nevertheless, one of the on-going debates about the testbed amongst technicians and educators has been the enterprise-side value proposition gained from the use of open source learning technologies. Given cost and accessibility, much analysis and discussion occurred on the replacement of the Fourpoint™ LDS with an open source solution. Extensive research and analysis had already been completed in previous research by the UNITAS Knowledge Centre (UKC) on the value and attributes of such 'free' Course Management Systems (CMS) or LMS' as:

- Moodle™ (http://moodle.org)
- ATutor™ (http://www.atutor.ca)
- Wordcircle™ (http://sourceforge.net/projects/wordcircle/)
- OpenLMS® (http://openlms.sourceforge.net/)
- Claroline® (http://www.claroline.net/)
- DoceboLMS™ (http://www.docebolms.org/)

Overall the challenges to the claim that open source learning applications are 'free' have been well documented. The risk of adopting such technologies and converting and maintaining them involves eventual costs usually equivalent to the purchase price of commercial learning technologies.

It is also worthwhile noting the strength in Moodle™ and Atutor™ beyond their technical design. The existence of user groups that span the globe and share experiences and solutions, endorsement by major international bodies (e.g. WorldBank for Moodle™ and Commonwealth of Learning for Atutor™), the development the multi-language support, and the emergence of technical support companies (in over 90 countries in Moodles' case), all suggest adoption is growing.

On the other hand some experts hold negative views. Many consider the open source LMS/CMS solutions very rudimentary. These views are best summarised by Paul Wilson from Knowledge Patterns (http://www.knowledgepatterns.com/). Comments he made during the research phase can be extrapolated as follows:

> *The very unformed design and build for these applications seems to stem from learning practitioners with programming skills possibly having a poor awareness and understanding of the broader ICT field. Even on a cursory evaluation of the systems {as listed above} suggest they do not understand the other options that exist for achieving the 'learning' functionality they require. This may be traced back to considering 'learning systems' as something unique and different from other computer-based activities, and therefore requiring different systems. This paradigm is like requiring a specific word processor custom-designed for teaching materials, whereas the overall design of word processors already streets ahead of any custom design that might be desired, and a standard word processor would work perfectly anyway. It would seem more useful to think of any learning system as one application of Knowledge/Content Management Systems technologies. If this is valid, it suggests the following:*
>
> - *Developing dedicated learning systems may not be useful because they can be quickly outgunned by dedicated enterprise and Content Management Systems*

which will tend to have existing user bases, existing corporate investment/infrastructure, and higher potential for linking with existing/emerging corporate systems (even lower priced LMS/CMS', which certainly appear more polished, are not necessarily highly advanced, and would be at risk when faced with such competitors); and therefore,

- *Designing an open source LMS independent of existing proven systems seems flawed.*

Boiled down to a pretty raw level of detail, the whole situation seems like an industry-wide dilemma and perhaps poor decision regarding a technology 'buy or build' decision … Given the rate of change that tends to occur in IT, and that each new innovation tends to open many new doors, it seems likely that already significant technology lag is likely to get more severe over time. In effect the competitive hurdle, and attractiveness of bypassing dedicated LMS solutions, is likely to increase to the point where it becomes competitively unsustainable.

The above comments relate to the comparative advantages associated with the use of both open source and lower cost enterprise applications that are more sophisticated. In many cases the LMS and student management activities can be added to these systems, or already exist to some extent within such systems. For larger organisations the implications of Paul Wilson's comments are perhaps worth noting. It is not the initial cost of the systems, or their rudimentary design that is the core issue. Acknowledging Paul Wilson's information systems expertise and focus on knowledge and content management systems that exist in the market, his concern centred on how well open source LMSs within an enterprise environment could:

- Scale up within known risk and cost parameters;
- Maintain the required pace of innovation and change all ICTs face when deployed;
- Integrate with other applications; and
- Comfortably fit within a cost effective organisational maintenance and systems development regime.

OKI

The need to ensure that data can move freely between different platforms and applications is a major issue for all e-learning standards regimes. The O.K.I.™ (Open Knowledge Initiative) is a Massachusetts Institute of Technology-led initiative to improve interoperability among applications and the enterprise system (http://www.okiproject.org/). The initial focus has been on higher education and e-learning, but the initiative's service-oriented architecture is applicable outside these domains. O.K.I.™ provides Open Services Interface Definitions (OSIDs): contracts between service consumers and providers. The OSIDs are well-defined integration boundaries that leave flexibility in the hands of developers. The OSIDs are neutral with regard to programming language[1] and implementation detail. Nevertheless, the Repository includes interfaces for integration among applications (consumers) and repository content (providers) (MIT, 2005:1). It also defines objects such as a Repository Manager, Repositories, Assets, and their metadata as well as methods for managing object lifecycle, data maintenance, and searching.

The O.K.I.™ work also compliments work in IMS Enterprise to ensure educational data management systems can not only interface better, but also do so with enterprise HR and related data management systems. IMS work and O.K.I.™also strongly influence Learning Technologies Systems Architecture (LTSA) work (http://ltsc.ieee.org/wg1/files/ltsa-400.html).

Applications use the OSID to gain access to content in a manner that hides the technical detail by which that content is provided. This allows the application to integrate simply with a wide range of content providers without including the complexity inherent in supporting

[1] The programming language-neutral form is of an OSID is called an XOSID. There are bindings of the XOSIDs for Java™, Objective-C, and PHP. Other languages bindings are in development.

heterogeneous means of communication and data exchange. The application is also insulated from technology changes made by providers which leads to a longer useful lifetime for an application and thereby a greater return on investment (MIT, 2005:1-2).

With regards O.K.I.™, the testbed has leveraged off the work by two of its technology suppliers in the international arena. HarvestRoad (Hive®) has worked on O.K.I.™with Apple Educational Marketing and MacLearningEnvironments.org (MLE.org). One joint plan was to have MLE.org build a Mac OS X application (SearchParty) that could search content in the HarvestRoad Hive®, a content store[2]. EtechGroup (Fourpoint®) have also been working with Apple Educational Marketing and HarvestRoad, who provide a standards-based learning management system to create the Global Learning Object Repository Initiative (GLORI). GLORI is a real-time global learning exchange based on e-learning standards and has several primary and secondary schools and universities involved as initial e-learning members.

The promise of O.K.I.™is worthwhile and seriously important given the findings of the first Stage of our research. It suggests specific architectures and application interface designs can be accommodated though use of meta architecture. In simple terms, rather than building an interface or application to ensure data management systems can 'talk' with each other, the aim is to build into all data management systems and data the means to connect and communicate. This confirms the move towards service oriented architecture, rather than fully integrated, stand-alone proprietorial systems. This is also consistent with major international project work funded and supported by the Joint Information and Systems Committee (JISC) in the UK. Projects that include the E-learning Framework (ELF) (http://www.elframework.org/), the implications for distributed learning explored in the Hull University DeL eTools - ASSIS (Assessment and Simple Sequencing Integration Services) (http://www.hull.ac.uk/esig/assis.html), or the Distributed National Electronic Resource (DNER) project (http://www.jisc.ac.uk/index.cfm?name=dner_adding_value).

The above ideas and current research strongly mitigate against standards and specifications regimes standardising how applications and technologies interoperate. It also strongly supports our Stage 2 development work that seeks to maximise how systems or applications deployed in an e-learning supply chain can communicate with, but operate independent of, any LMS or LOR.

Expanding the network utility and value

Metcalfe's Law states that the utility or value of a network grows by the square of the size of the network (i.e. number of users - $n(n-1)$, or $n^2 - n$). While this equation may overestimate the overall value every connection or additional function contributes, it does give an excellent guide to the value of adding users to a network. Conceptually the application of Metcalfe's Law to all learning management and related systems suggests that, as with any IT system, the more functions offered, the more useful and value-adding learning technologies can be. Therefore, it seems learning systems that can integrate with existing IT systems and add functions on offer to users, while also enabling data reporting that can contribute to multiple enterprises activities beyond learning, will consistently out-perform the value of dedicated learning systems in the market. In effect Metcalfe's Law works against the dedicated LMS developer and regimes that seek to standardise how learning applications and technologies interoperate in isolation to other systems. However, for developers that actively seek to build efficient, responsive, and service oriented solutions, Metcalfe's Law starts working in their favour.

[2] The goal was to show the application and Hive® working together. MLE.org chose to develop a native Mac OS X application, written in Objective-C, rather than a cross-platform application written in Java™. While the Java application would work on both Mac OS X and Windows, Objective-C programs can leverage the Cocoa developer frameworks native to Mac OS X thus speeding development time, allowing more focus on the user experience and the application functionality. SearchParty was to use a proprietary API provided by HarvestRoad (Java Hive API - JHAPI). This effort had an aggressive timetable and required some Objective-C/Java bridge work, but was not perceived to have a high degree of technical risk

M-learning: stretching the boundaries

Mobile learning offers an extended capability beyond delivery of e-learning using terrestrial communication networks and the World Wide Web. As stated by Bowles (2004: 15):

> *The emergence of mobile, wireless and satellite technologies is already impacting on e-learning. New Internet technologies are being used to support small-screen mobile and wireless devices. Satellites and mobile wireless devices can use TCP/IP (Transmission Control Protocol and Internet Protocol) to communicate on the Internet. In a field marked by such rapid evolution, we cannot assume that the Web as we know it today will remain the primary conduit for Internet-based e-learning.*

The promise of m-learning is challenging paradigms that have underpinned online learning. This especially relates to the design of content and the need for educators to become more familiar with the technical differences associated with mobile information and communication technologies. This is encapsulated in the following observation from Nokia:

> *Yet despite the many benefits of mobility, no one today seems content with the state of corporate content (the various forms of on-line information)—especially the rendering of existing PC-oriented formats on handheld devices. Workers using smaller devices with their smaller screens often get frustrated attempting to access available information. And once connected, they can get even more discouraged trying to navigate the "full screen" nature of email messages and attachments … (Nokia, 2004:1),*

In spite of the hurdles associated with m-learning, mobile networks and devices have long been considered a major opportunity for enterprises to expand how they communicate and transfer knowledge. The networks also extend beyond fixed Internet to offer employees on-demand access to the data, information, knowledge, and learning the company can access. This means value for the company resides not only in the improved performance such networks can generate, but also increases the utilisation of existing knowledge assets in a manner that tangibly expands the organisation's operational capabilities.

From an m-learning perspective this suggests an investment in content and systems for learning purposes has a value that does not reside solely in the learning outcomes. It resides in the ability to manage the personalisation and delivery of knowledge assets in a way whereby it is possible to report the affect this knowledge transfer has had beyond individual learning. This includes recording and reporting data that confirms improvement in individual performance, customer satisfaction, and the expanding value resident in the origination possessing the capacity to deliver knowledge assets in a way that increases their intrinsic capital value.

The attributes of m-learning identified in research includes:

- **Ubiquity of access** – independent access anytime, anywhere
- **Convenience**– time and space constraints are removed and people can access applications to their time and preferences
- **Security** – use of means such as Security Socket Layer (SSL) to provide personal security, privacy of communications, and data integrity above that available in fixed Internet environments.
- **Localisation** – merging capabilities and sharing costs between retailers or a region wishing to 'push' or promote mutual services and products
- **Instant connectivity** – access to applications on demand using multiple technologies and more network option.
- **Personalisation** – use of multiple technologies to receive what you want, to set preferences, and how you want, while allowing the provider to place content and brand directly to the user in their context (positioning control, targeting and culturally sensitive).

Some attributes inherent in mobile communication deployments in areas such as e-commerce and e-knowledge that are still to be fully appreciated in the m-learning field include:

- **Telemetry and passive data capture for:**
  - Status, sensing and measurement data
  - Learner access (tracking, navigation systems, information tied to locations, and positioning)
  - location triggered learning
- **Interoperability bridge:**
  - Wireless phones with various devices
  - Mobile/Wireless/Satellite reception and linkage into fixed internet through same device
  - Assessment tied to knowledge management
  - Scanning of items and other applications on 'device' integrate work functions with learning activities
- **Lifestyle advantages**
  - Promote wider access (inclusiveness)
  - Remote monitoring (eg. security systems, etc.)
  - Communication (telephony, VoIP, data…)

Many limitations of m-learning have also been confirmed as part of the initial work on moving content developed for PC access (either online or via CD ROM) into a form usable on small screen devices such as PDA, small laptops and even smart phones. Limitations to consider include:

- Small screens
- Standards guiding technology connection(s) and data interchange on mobile devices
- Slow convergence of functionality between mobile Internet over mobile phones, handhelds and mobile computers
- Slow appreciation of Australian satellite broadcasters on the market for digital learning beyond fixed connections (TV and cable)
- Limited roll out of higher bandwidth mobile networks and devices (i.e. 3G networks and wireless broadband networks are predominantly located in cities)
- Sunken costs in 'old' wireless and broadband infrastructure
- Technology constraints of mobile devices (memory, processing power, display capabilities, input methods)
- Security of data when moved between some mobile and wireless networks
- Too many choices for business investment in hardware and infrastructure

Mobile Learning Environments (MLE)

The prevailing assumption has been that m-learning requires both content be accessed and assessment to be reported back to an LMS. As such, m-learning has to consider how to splice any learning activity on a mobile device with a link to the LMS. The concept of an MLE devised by Bowles (2004:155), suggests learning must be optimised by balancing the competing requirements of lower bandwidth while still enhancing interactivity and engagement. The addition of an LMS functionality to the portable computing device, whether through a storage card (SD Card) or via online links, mitigates against both ease of use and bandwidth issues.

Uncoupling mobile learning content from the LMS is at the heart of creating an MLE. Being online is also discouraged in favour of synchronisation; a solution widely deployed in m-commerce but still relatively embryonic in m-learning deployments.

As illustrated in the figure below, delivery of content and assessment of outcomes can be completed in an MLE separate to the LMS. Equally, the learner need not be online all the time if the content can be pre-loaded or downloaded onto the mobile device and assessment or other tracking data synchronised back to a database.

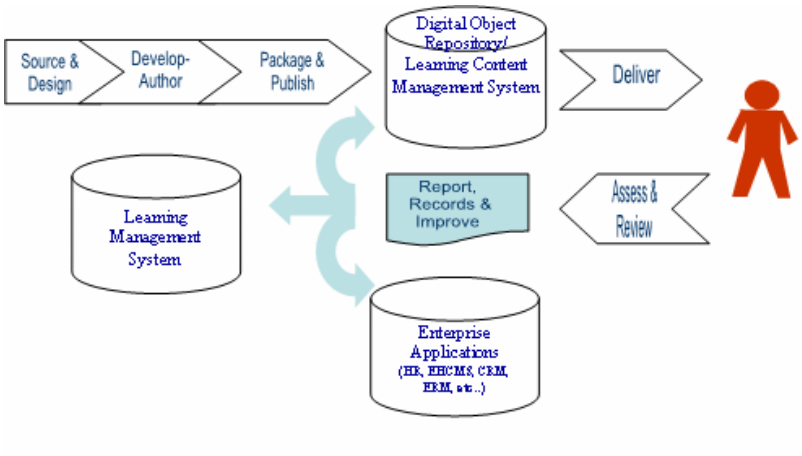

Figure 1 Uncoupling the LMS from m-learning solutions

The above hypothesis is reinforced by the examination of mobile assessment. While research has confirmed learning objects need to be better managed beyond the LMS, it has also presented a tantalising insight into the benefits of integrated results reporting beyond the LMS. The value generated by a LOR beyond learning (i.e. Knowledge asset value, content management, etc.), has to be matched by better management of the data resulting from learning completion.
In the first instance, Stage 1 of the testbed confirmed how LORs offer distinct value propositions in terms of their contribution beyond earlier learning content management systems (LCMSs). LORs, such as Hive®, are able to manage granular digital objects for reuse in learning (and other contexts), and do so in a federated manner across multiple authoring and delivery environments. Typically, LCMSs assumed integrated authoring and usually directly embedded this functionality with an LMS; no granularity and certainly no federation.

While some 'out of the box' LMS'scan and do interface well with enterprise applications, value is increased significantly where data can move across any compliant database. As depicted below, the first figure shows mobile workers (including assessors) reporting results back to the organisation online or via synchronisation within the corporate secure network. The data reported from each activity is directed to each relevant application. To share data one application must integrate with the other application. Integration across the whole network is costly and often very difficult. For instance, assessment results go into the LMS, but reporting the assessment as a pay or service outcome requires an interface be built between the HRMIS and the CRM.

In the second evolution the mobile network is in effect the Internet accessed anywhere, at anytime. For mobile assessors the data they capture can be synchronised back to a central enterprise server and database. If this central database was, for instance, compliant with IMS Enterprise standards it could report learning information into fields that could then directly report or share data with any compliant application in the enterprise network. In such a scenario assessment results once keyed/captured will direct data to any relevant enterprise application.

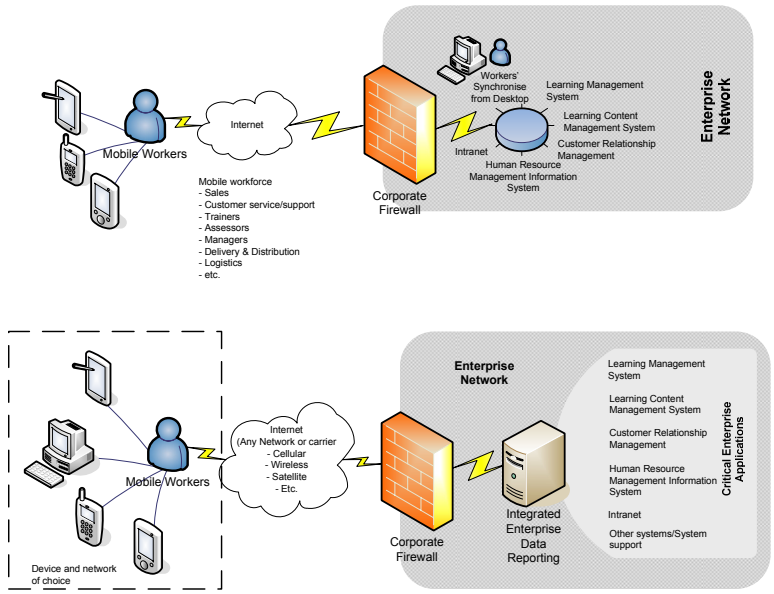

Figure 2 Evolving data integration and reporting from mobile assessment

Accessibility

In the same way that modern offices and public buildings have ramps for wheelchair access and Braille on elevator buttons that make entry and navigation easier for those with a disability, modern websites have analogous features that make the site easier for those with disabilities. Like old buildings, some websites are almost inaccessible for those in a wheelchair, or un-navigable for the blind.

Web Accessibility is about designing and coding sites that do not exclude users who are blind, or who cannot use a mouse. It's not difficult to do, but in the same way that it's easier for a builder to build a new house with 32inch-wide doors to allow wheelchair access than it is for the same builder to convert an existing house to have wider doors, it's much easier to design your web site to be accessible than it is to alter it once it's been designed and built.

HTML has always been 'accessible' because it was designed to deal with text. During the browser wars, however, more and more proprietary tags were used, and screen readers generally don't like non-W3C tags. Also, due to a natural urge to make designs as precise as possible, pages were bloated with spacer gifs and nested tables, all of which make it very difficult for a screen reader to comprehend.

Designing accessible content
The development of the Diploma of Business (Frontline Management) into a fully online, accessible form provided some important lessons. These included the following:

- Content that does not use Flash® or bandwidth hungry animations does not have to be boring. The course was developed to be used for blended delivery. This means it is an online version of the course notes and all resources that supplement face to face delivery. It is not intended to be interactive content. Nevertheless, it has some important design features that maximise its utilisation:
    - Content is ‘chunked’ into easy to complete blocks.
    - Each block relates to a stand alone sub-topic within a larger topic area.
    - Each topic area has its own reflective quiz and supporting presentation that give an overview of all the sub-topics.
    - Navigation is accessible and can take the learner to specific related components of learning.

    - Content is reflective of, but not necessarily presented exactly the same as, hardcopy student notes.
    - Content is packaged into SCORM or IMS at the 'block'/sub-topic level to maximise tracking, reuse and student access.
- Moving content into accessible form on a CSS is best achieved when the MSWord® document is also produced in a parallel template with all Alt Tags on images and heading formats set.
- Content does not have to be difficult to produce in accessible form (W3C level 3). The development of the course was achieved through rigorous trial and error that resulted in the development of an accessible CSS template(s). This template can be reused for other courses and modified to achieve different design features or outcomes. The important add-on work such as ALT labels for images were resolved by the original author, ensuring paragraphs leading into an table or figure fully explain the figure.
- Navigation solutions exist. The problems with navigation were resolved through international research that led to a number of solutions that have specifically been designed to resolve how people with visual or learning disabilities navigate online learning content. These products were tested and the best solutions licensed or built into the templates being used.
- Aptitude Media's James Newton, and Adam Maxwell (March, 2005) identified a checklist to ensure accessibility is achieved:
    - Use standard markup; HTML 4.01 or XHTML (transitional or strict).
    - Use CSS to separate styles from the content
    - 'Caption' pictures with the alt attribute; in a visual browser this looks like a 'tool tip' when you mouseover an image; a screenreader reads the alt text to the user. Make sure the text is meaningful.
    - Ensure that text can be resized . For users who are not blind, but have visual impairments, this is vital. Not everyone is a 20-year old designer with perfect eyesight and a 21inch monitor!
    - Don't rely on JavaScript. There's no problem with JavaScript, but don't rely on it for navigation, because screen-readers, PDAs etc don't understand it.
    - Ensure your forms are Accessible , otherwise the user won't be able to contact you, sign up for your newsletter or buy your wonderful product. There's an article by Rachel Andrew "Forms and Accessibility" at DNzone.
    - Use a tab index to ensure that the user can tab through fields in a logical order.
    - Use Accesskeys . They're supported in all modern browsers, allowing the user to press a designer-determined key to open links. You can use a CSS class to underline the letter of the Accesskey to let users know which key you have assigned (like the underlining sign for the shortcut key in "F o rmat" in the Microsoft Word menu, for example).
    - Ensure Accessible navigation : Don't use drop-down menus for navigation without a 'go' button to confirm the selection. Such navigation is impossible to use without a mouse. Also, warn users before spawning new windows, or they might be trying in vain to use the 'back button' when actually they're in a new window.
    - Put the most important content at the top of a page . Sighted users can 'scan' a page for the main body of content; a person with a disability must listen to a screenreader read the site from top to bottom, and could be listening to a lot of links, and logos before hearing the main content that they care about. If you can't do that, make the first item on the page a link "skip to main content" and make it invisible by having the same colour font as the background colour. Your sighted users will never know it's there; blind users will hear it on their screenreaders and thank you for it!
    - Test your pages for Accessibility . When you've finished, check the page. By all means use UsableNet's LIFT tool, the Bobby or Cynthia Says validators but they are only machines. View your site in the Lynx browser or, better still, download a speech synthesiser and then check out your site with the monitor turned off and the mouse unplugged.

Assessment and IMS QTI®

QTI is the **Q**uestion and **T**est **I**nteroperability specification developed by **IMS** Global Learning Consortium, an international, industry sponsored project. QTI described how questions (assessment items) and tests (assessments) results can be described in XML. QTI version 2 was released in February 2004. The new standard is a quantum evolution beyond Version 1.2. QTI is essential in detailing how to achieve interoperability of assessment instruments and all aspects of data reporting off mobile devices.

For the past two years Dr Marcus Bowles from Working Futures™ has been lobbying and actively advocating the treatment of assessment as an object that is able to be packaged and managed independent of other objects (i.e. a learning resource or content package). This was considered essential for management of assessment where it was tied to compliance or holistic requirements that spanned more than one learning activity (i.e. a module, course, etc.). While still in its very early days, this requirement is now possible.

Stage 1 of this research project has identified a number of factors that will reshape effort in Stage 2 development work:

- Workflow analysis suggests the creation (authoring) or conversion of assessment objects to IMS QTI® Version 2 is most likely to be adopted and completed with a high degree of efficiency and effectiveness where the author can do this on their own desktop.
- Workflow analysis suggests the reporting of outcomes from use of an assessment object (IMS QTI® Version 2 report file) is most likely to occur with a high degree of efficiency and effectiveness where it can be synchronised back to a data management systems. In a mobile environment this especially prevents the need to be online, all the time.
- LMS vendors in the main are suggesting authoring of QTI® Version 2 assessments will be possible on their systems from 2006. However, few systems currently have plans released that span more than knowledge tests. It is suggested QTI® version 2 should encompass at least 20 main typologies of assessments and permit the mixing and construction of assessments that combine different question typologies (i.e. Short answer and competency checklists).
- Assessments need to be created and managed separate to learning objects and while still carrying the metadata that permits them to be managed just as with any other object or SCO (i.e. Assessment should not just be embedded within a learning object),
- It must be possible to have multiple activities or SCOs tied to one assessment object.
- QTI® assessments (assessment objects) must be able to be labelled, edited and packaged using various other e-learning standards compliance regimes (i.e. SCORM, or national variations such as VETADATA -Vocational Education and Training Metadata Application Profile and VLORN project requirements - www.flexiblelearning.net.au) to maximise their reuse, accessibility, discoverability, durability and interoperability (including across multiple applications such as LOR's and LMSs).
- Creation of assessment objects and the reporting of outcomes from deployment of a QTI® assessment must not be tied to any one LMS or Student Information Management System (i.e. Service oriented architecture should be deployed).
- Most importantly, all data reported from assessment can be managed in XML to the highest security and privacy requirements, across fixed, wireless, cellular, satellite, or cable networks.
- Develop and test additional vocabularies (i.e. Enterprise HR reporting such as Human Capital).

It is also important to note that assessment under QTI® requirements also offers attractive ways to complete knowledge assessment and information surveys. For commercial and enterprise systems administrators QTI® compliance can integrate learning assessment with pay, performance and human capital reporting. Delivery can also move beyond fixed Internet

networks to encompass mobile networks. It provides a means to conduct both knowledge and learning transfer in a manner that does not 'burden' the existing, often overburdened internal networks. It also can be done in a manner that does not compromise security, commercial and privacy concerns. Additionally there is no need for the LMS to actually reside inside the enterprise's own network. Data can be interchanged in XML from the mobile devise to the learning providers' systems and thence, through a very secure, narrow 'tunnel' to the HR, learning, knowledge and related enterprise data management systems.

Foundations for Stage 2

In Stage 1 Action Research has provided stand-alone and cumulative evidence that using open, standards compliant technology and processes enhance the value proposition from an enterprise, end-to-end e-learning intervention. The value of technology and content increases as reuse expands, interoperability is enhanced and implementation can occur without dependence on any one technology. Stage 2 MUST LEVERAGE OFF Stage 1 research and findings. It will centre on confirming the reach of the e-learning supply chain and identifying where value can be enhanced through learning and knowledge transfer processes within both learning providers and enterprises.

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Web Sites

Aptitude Media	http://www.aptitudemedia.com
O.K.I.	http://www.okiproject.org
Apple Education	http://www.apple.com/education
eduSource Canada	http://www.edusource.ca
EtechGroup	http://www.etechgroup.com.au
Giunti Interactive Labs	http://www.giuntilabs.com
HarvestRoad	http://www.harvestroad.com
IMS Global Learning Consortium	http://www.imsglobal.org
Institute for Working Futures	http://www.workingfutures.com.au
Institute of Electrical and Electronics Engineers (IEEE)	http://www.ieee.org/portal/site
Intelitec Pacific	http://intelitec.com.au
Joint Information Systems Committee (JISC)	http://www.jisc.ac.uk/
Mac Learning Environments	http://www.maclearningenvironments.org
The Knowledge Exchange	http://www.tke.com.au
TKE Testbed	http://www.marcbowles.com/tke/about.htm
Sakai	http://www.sakaiproject.org

Attachment 1 Case study template

The Knowledge Exchange Testbed

Research Case Studies

{Title of the case study}

by {*Author's name(s)*}[+]

1. **Summary**

2. **Purpose**

3. **Context**

4. **Key issues or hurdles**

5. **Solutions**

6. **Lessons and implications**

7. **Contact Information**

Key players	Author

8. **References**

9. **Attachments**

[+] AUTHOR'S DETAILS