towards a 21st century national software infrastructure for education
strategic ICT advisory service
Acknowledgements

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Foreword

Several significant current trends are providing strong imperatives for Australian policy makers to seriously consider Australia’s national software infrastructure for education, including the 21st century learning agenda, issues of equity and social inclusion, Australia’s innovation, collaboration and productivity agendas, and the constant emergence of new technologies. This investigation develops the case for acceleration of Australia’s progress towards a 21st century education software infrastructure.

The report presents analyses of the policy drivers outlined above and of the current state of Australia’s national education software infrastructure. On the basis of those analyses, recommendations are made for actions that will accelerate the development of Australia’s education software infrastructure towards a situation in which the policy drivers identified are addressed, and emerging issues and agendas can be more efficiently tackled in future.

Australia’s federation is a key consideration for policy makers in education, and recommendations from this investigation are appropriately framed to build on work already carried out in the states and territories.

This investigation is one of the series commissioned by the Australian Government’s Department of Education, Employment and Workplace Relations (DEEWR) as part of the Strategic ICT Advisory Service (SICTAS) project.

I commend this report and its recommendations to the reader.

Greg Black

CEO Education.au
# Table of Contents

1. Glossary .............................................................................................................................. 3
2. Executive summary ............................................................................................................. 6
3. Recommendations ............................................................................................................... 9
4. Introduction ........................................................................................................................ 16
5. What a national 21st century software infrastructure would look like ......................... 18
6. What has been done and what still needs to be done ..................................................... 28
7. Conclusion ......................................................................................................................... 40
8. Appendix A: Drivers for 21st century software infrastructure ....................................... 41
9. Appendix B: National and international initiatives .......................................................... 50
10. Bibliography ...................................................................................................................... 60
11. Endnotes ........................................................................................................................... 68
## Glossary

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>AAF</td>
<td>Australian Access Federation</td>
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<tr>
<td>AARNet</td>
<td>Australia's Academic and Research Network</td>
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<td>ACARA</td>
<td>Australian Curriculum, Assessment and Reporting Authority</td>
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<td>ACCI</td>
<td>Australian Chamber of Commerce and Industry</td>
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<td>ACE</td>
<td>Adult Community Education</td>
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<td>ACODE</td>
<td>Australasian Council on Open, Distance and e-Learning</td>
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<tr>
<td>ACT</td>
<td>Australian Capital Territory</td>
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<tr>
<td>AESOC</td>
<td>Australian Education Systems Officials Committee</td>
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<td>AGIMO</td>
<td>Australian Government Information Management Office</td>
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<td>AICTEC</td>
<td>Australian ICT in Education Committee</td>
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<td>ALGA</td>
<td>Australian Local Government Association</td>
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<td>ALTC</td>
<td>Australian Learning and Teaching Council</td>
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<td>ANTA</td>
<td>Australian National Training Authority</td>
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<td>AQTF</td>
<td>Australian Quality Training Framework</td>
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<td>ARIIC</td>
<td>Australian Research Information Infrastructure Committee</td>
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<td>ARROW</td>
<td>Australian Research Repositories Online to the World</td>
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<tr>
<td>ASTEC</td>
<td>Australian Science and Technology Council</td>
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<tr>
<td>BCA</td>
<td>Business Council of Australia</td>
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<tr>
<td>Becta</td>
<td>formerly the British Educational Communications and Technology Agency</td>
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<tr>
<td>CAUDIT</td>
<td>Council of Australian University Directors of Information Technology</td>
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<tr>
<td>COAG</td>
<td>Council of Australian Governments</td>
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<tr>
<td>COLIS</td>
<td>Collaborative Online Learning and Information Services</td>
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<tr>
<td>CTL</td>
<td><em>Collaboration in teaching and learning</em> Report</td>
</tr>
<tr>
<td>DCSF</td>
<td>Department for Children, Schools and Families (UK)</td>
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<td>DECS</td>
<td>Department of Education and Children’s Services</td>
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<tr>
<td>DEEWR</td>
<td>Department of Education, Employment and Workplace Relations</td>
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<tr>
<td>DER</td>
<td>Digital Education Revolution</td>
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<tr>
<td>DEST</td>
<td>Department of Education, Science and Technology</td>
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<td>DETER</td>
<td>Department of Education Training and the Arts</td>
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<tr>
<td>DFEEST</td>
<td>Department of Further Education, Employment Science and Technology</td>
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<tr>
<td>DIES</td>
<td>The UK Department for Education and Skills (replaced by the Department for Children, Schools and Families and the Department for Innovation, Universities and Skills) (UK)</td>
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<tr>
<td>DIISR</td>
<td>Department of Innovation, Industry, Science and Research</td>
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<td>DIUS</td>
<td>Department for Innovation, Universities and Skills (UK)</td>
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<tr>
<td>e-Framework</td>
<td>e-Framework for Education and Research</td>
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<td>FLAG</td>
<td>Flexible Learning Advisory Group</td>
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<td>Framework</td>
<td>Australian Flexible Learning Framework</td>
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<tr>
<td>FRODO</td>
<td>Federated Repositories of Online Digital Objects</td>
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<tr>
<td>FTTP</td>
<td>Fibre to the premises</td>
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<tr>
<td>ICT</td>
<td>Information and communications technology</td>
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<td>IT</td>
<td>Information technology</td>
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<td>KERIS</td>
<td>Korea Education and Research Information Service</td>
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<td>LEA</td>
<td>Local Education Authority</td>
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<td>LIMA</td>
<td>Learner Identity Management Architecture</td>
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<td>LIMF</td>
<td>Learner Identity Management Framework</td>
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<tr>
<td>LORN</td>
<td>Learning Object Repository Network</td>
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The focus of this investigation is national and cross-sectoral. The word ‘institution’ is used throughout to refer to state and territory education jurisdictions and to learning institutions in all Australian education sectors.
Australia is well positioned to be a leader in the provision of 21st century technology enriched education.

We are already well advanced in the provision of much of the required underpinning national software infrastructure to support 21st century learning.

The next key step forward is the enhancement of existing investments in national education software infrastructure to support seamless integration with emerging internet ‘cloud computing’ models and closer integration with the learner’s existing online Internet identity and services.

This will enable and drive our national capability to provide 21st century technology-enriched learner-centric services such as safe, secure collaborative learning seamlessly across geographic, jurisdiction and sector boundaries.

Adding support to existing advisory bodies with an ongoing operational capability in areas such as interoperability standards, tracking of emerging technologies, facilitation and outreach will accelerate development and help to sustain and maintain the infrastructure in a rapidly changing technical environment.

2.1 Technology enriched learning

The Australian Government has committed that the nation will have 21st century technology enriched learning environments. This is a strategic recognition of the central role that technology plays in educating our citizens to become a digitally literate workforce.

This paper investigates what is needed in terms of national software infrastructure to support 21st century learning. A particular emphasis of this investigation is the nature of software infrastructure that will be needed to support emerging internet ‘cloud computing’ models and Web 2.0 style learner-centric collaborative learning services.

Technology enriched 21st century learning is characterised by:

- learners connected 24x7 to their online learning “cloud” via high speed broadband and wireless networks
- educators and learners engaging in collaborative learning activities across jurisdictional and geographic boundaries seamlessly, safely, and securely
- learners accessing learning services and resources from multiple learning providers, nationally and internationally
- life-long learner transition from primary school to secondary school to vocational education and training (VET) or university and to the workforce.

2.2 Commitment to infrastructure

The Australian Government's National Broadband Network (NBN) initiative represents a national strategic recognition of the central importance of the internet to the nation’s economic and cultural
prosperity. It will be a key nation-building hardware information and communications technology (ICT) infrastructure project that will position this country well to compete in the 21st century digital online global economy and provide a key enabling platform for new modes of technology enriched learning. This platform has been further strengthened by the announcement of funding for a high speed broadband network for the vocational education and training sector, the Vocational Education Broadband Network.

The Digital Education Revolution (DER) policy provides for the release of significant funds to further leverage the power of technology to improve teaching and learning in the school sector. Key components of the DER strategy are to build up the nation’s hardware and software infrastructure to support and enable 21st century learning.

2.3 The internet drives out notions of e-learning infrastructure

The internet is moving rapidly towards a ‘cloud computing’ model in which services are provided from the internet ‘cloud’ rather than from software on users’ computers or in-house software provided internally by institutions. This model is driving the notion of the ‘personal web’ and is challenging organisations to re-think the business effectiveness of in-house provided computing infrastructure.

These emerging internet models are key drivers for our understanding of what 21st century technology-enriched learning should look like. Two key characteristics discussed in this paper are the shift from an institution-centric towards a person-centric approach to the provision of e-learning services and closer integration with the learner’s existing online internet identity and services.

Today, students have an online identity, access to the latest online mobile devices, and already participate online in a variety of formal and informal online networks, giving them access to global communities and resources and enhancing and enriching their daily living and their informal learning. These students have an expectation and right to expect that their formal learning experiences will be equally engaging, technically rich and relevant to their daily online lives.

2.4 A 21st century national software infrastructure for education

In order to provide this technology enriched national learning capability a supporting 21st century approach to national software infrastructure is required. This infrastructure should be focused on connecting and enabling services from multiple providers to meet learner needs. It should deliver learner-centric services seamlessly across geographic, jurisdictional and sectoral boundaries.

Key components of this national software infrastructure are:

- an ‘education cloud’ based on the internet ‘cloud computing’ model
- learner-centric approach to digital identity
- support for collaborative learning
- support for secure data interchange
- support for seamless resource discovery

The infrastructure should be based on a nationally agreed set of interoperability standards and governance, leadership and operational processes to ensure that the national infrastructure is developed, sustained and enhanced to keep pace with constantly and rapidly changing technology.
2.5 Building on existing infrastructure

There has already been considerable progress made towards building this software infrastructure. Key initiatives have included Education Network Australia (edna), the Australian Access Federation (AAF), the Learner Identity Management Framework (LIMF), the Australian Flexible Learning Framework (Framework), the Learning Object Repository network (LORN), Australian Research Repositories Online to the World (ARROW), Persistent Identifiers (PILIN), and the Schools Interoperability Framework (SIF).

Today we have national software infrastructure that incorporates elements of identity, secure access, content discovery and interoperability standards, but these elements are mostly specific to single sectors of education and are institution-centric in nature.

This investigation’s recommendations relate to extending the existing national software infrastructure and supporting operational processes to support 21st century models of user-centric collaborative learning services, operating securely and seamlessly across geographic, jurisdictional and sectoral boundaries.

These are described in the following recommendations section.
3 Recommendations

This paper investigates what is needed in terms of national software infrastructure to support 21st century learning. A particular emphasis of this investigation is the nature of software infrastructure that will be needed to support Web 2.0 style learner-centric collaborative learning services.

The Australian Government has a key role to facilitate the development and ongoing sustainability of a 21st century national education software infrastructure. Twenty-first century learning infrastructure has been identified as a key priority area for further work in the Australian Government’s Digital Education Revolution (DER) initiative.

Considerable progress has already been made towards building a national software infrastructure for education. Today we have national software infrastructure that incorporates elements of identity, secure access, content standards and interoperability standards. Much of this infrastructure is specific to a single education sector and is institution-centric in nature. Examples include:

- Australian Flexible Learning Framework (Framework)\textsuperscript{10} initiatives such as the Learning Object Repository network (LORN),\textsuperscript{11} and E-standards\textsuperscript{12} in the VET sector
- Australian Research Repositories Online to the World (ARROW),\textsuperscript{13} focused on supporting interoperability of institutional repositories for the higher education sector
- the Schools Interoperability Framework (SIF)\textsuperscript{14} project that will interconnect institutional administration systems in the school sector
- the Meta Access Management System (MAMS)\textsuperscript{15} and the Australian Access Federation (AAF)\textsuperscript{16} projects have delivered institutional identity and access control infrastructure in the higher education sector.

These initiatives have all contributed to necessary and fundamental underpinning infrastructure to support the business of education.

However, to support technology-rich 21st century learning, existing institution-centric national software services need to be complemented and extended by services that:

- are focused on learners and educators
- are user-centric in nature
- are modelled on and seamlessly integrated with modern Internet Web 2.0 and cloud services.

These learner-centric services can be thought of as an education cloud: a user-centric set of services based on the internet cloud computing model that supports anywhere, anytime access to learning across geographic, jurisdiction and sector boundaries.

Three key actions are recommended as the next steps forward towards developing the 21st century national software infrastructure for all sectors of education and training:

- add support for collaborative interoperability
- extend the national trust fabric
- develop a national capability to provide ongoing support and enhancement of the infrastructure in a rapidly changing technology environment.
The focus of these recommendations is building on what has already been achieved in national software infrastructure for education. Analysis leading to these recommendations is contained in the subsequent sections.

**Recommendation 1: Develop a national cross-sectoral collaborative interoperability service**

Education.au’s me.edu.au service (also available as a stand alone tool known as FusED) provides a national Web 2.0-style ‘Facebook for educators’ service. This is a particularly valuable way to allow educators to connect and collaborate across jurisdictional and sector boundaries and provides support for many smaller stakeholders that are outside the mainstream large state-based jurisdictions.

Jurisdictions are also beginning to implement Web 2.0 style collaborative, social networking environments to support teacher professional learning and student collaborative learning. However, these implementations largely allow collaboration only within jurisdictional boundaries.

Work needs to be done to reach agreement on standards for inter-connecting collaborative (social networking) environments to enable true national secure collaboration across jurisdictional and sectoral boundaries.

Pilots and trials should be commenced to determine the appropriate standards and technologies to support interoperability of collaborative environments across jurisdictional and sectoral boundaries. Key candidate technologies and open standards are those often referred to as the ‘Open Stack’ and in common use in popular Web 2.0 social networking sites.

Work is already underway in this area. Trialling is commencing with Education.au and the NSW VET sector implementing an in-house version of the FusED social networking tool.

It is recommended that that this trialling be extended to cover a number of jurisdictions across the sectors and to include aspects of interoperability between different collaborative tool implementations. The trial should include social networking tools (such as FusED) that are already based on some Open Stack standards, easily extensible to the full Open Stack suite and customisable for integration with other elements of the national software infrastructure such as trust fabric technologies. This trial would be used to achieve a number of objectives:

- provide a tool for educators to collaborate for professional learning and peer support
- demonstrate the use of Web 2.0 tools for teaching and learning
- demonstrate standards-based interoperability between devolved collaborative tool implementations
- demonstrate the integration of Web 2.0 user-centric Open Stack standards with trust fabric technologies to support safe, secure collaboration across institutional and sector boundaries.

These activities could initially be resourced as a DER initiative within the National Interoperability and Digital Architecture Advisory Group’s (NIDAAG) 21st century learning priority work area and should involve collaboration with leading experts from within the education and training sector as well as industry.

In order to support safe, secure collaboration an extended national trust fabric will be required. This is detailed in the following recommendation.
Recommendation 2: Develop a national cross-sectoral trust fabric to support secure learner-centric identity and access management.

The Meta Access Management System (MAMS)\textsuperscript{20} project demonstrated a trust federation business model and Shibboleth technology to create a national trust fabric for the Australian higher education sector by interconnecting the various institutional identity management systems to provide strong levels of authentication and access control across jurisdictional boundaries. Considerable work has been undertaken to develop the business, legal and operational models that are required to provide a robust federated trust fabric across the higher education sector. This work led to the formation of the Australian Access Federation (AAF) for higher education.

The suitability of the higher education trust fabric for the school and VET sectors has been reviewed. This has revealed that in recent years new Web 2.0 approaches to identity and trust have emerged, the most notable being OpenID\textsuperscript{21} and Identity Meta-system approaches using Information Cards.

Some progress has been made in these sectors:

- There has been interest by some state school jurisdictions and Catholic schools in looking at implementing the key AAF Shibboleth technology.
- The VET sector LORN project is looking at a trust fabric to provide authenticated access to commercial learning objects within the VET sector.
- The school sector Scootle\textsuperscript{22} system has investigated OpenID technology as a light-weight approach to authentication.

Education.au has previously provided advice\textsuperscript{23} to the Australian Government about extending the concept of the higher education sector AAF into a trust federation for the VET and schools sector.

Much of this previous advice is supported here as this investigation has determined that a whole-of-education-sector trust fabric is a fundamental enabling platform essential to delivery of effective 21\textsuperscript{st} century learning services allowing learners and educators to connect securely and safely to their peers and resources across geographic, jurisdiction and sector boundaries.

While Web 2.0 social networking sites, technologies and standards provide rich opportunities for collaborative learning they currently do not provide the robust authenticated models for identity and trust that will be required to support collaborative learning and other services in education.

Learning institutions, through their internal enrolment processes and identity management systems, can provide this high level of authentication about identity and roles for learners and educators.

It is timely to re-investigate the best technical approaches to providing this trust fabric with a view to determining how to leverage the ease of use and global reach of Web 2.0 approaches while supporting the high levels of authentication and trust that exists within institutional identity management processes and systems.

a) Commence trials to inform the integration of institutional authenticated identity systems with Web 2.0 user-centric identity approaches

Although the technologies and standards for both institutional identity management and Web 2.0 style user-centric services are both robust and mature, the methods of integrating these two models are not yet well known or proven. So much of the early work in building this integrated infrastructure will involve pilots and trials.
Pilots and trials should be resourced involving all three sectors of education to look at ways to extend the work done by the MAMS project in terms of Shibboleth-based organisation-centric approaches to trust networks to include interoperability with Internet Web 2.0-style person-centric identity and access services such as OpenID and emerging identity meta-system approaches.

The objectives of these trials would be to:

- obtain and independent expert review of technical options including Shibboleth, OpenID and meta-identity approaches.
- trial a Web 2.0 user-centric approach to identity management and access control using Web 2.0 technologies such as OpenID and Identity Meta-system approaches such as Information Card.
- investigate opportunities for interoperability between these user-centric Web 2.0 and the institution-centric Shibboleth approaches to identity and access control
- demonstrate how this infrastructure can be used to support secure, user-centric collaborative learning applications that cross institutional and sector boundaries. Example applications could include connecting social networking systems for collaborative student learning and educator professional learning, access to directories of educators and a system for educators to share and recommend resources.

These activities should involve collaboration with leading experts from within the education and training sector as well as industry.

A key objective of these trials is to prove and develop learner-centric digital identity services that integrate institution-centric identity services with Web 2.0 identity services to enable learners to seamlessly integrate their institutional and personal Internet identities in a secure manner.

b) Establish a national cross-sectoral trust fabric

Once the technical approaches to creating secure learner-centric services for identity and access have been agreed, the next steps are to establish the appropriate legal and operational elements of the national trust fabric and facilitate take-up of this service by all stakeholders including:

- higher education institutions
- state school jurisdictions
- Catholic Schools
- independent Schools
- TAFEs
- smaller stakeholders such as ACE, early childhood, as well as smaller Registered Training Organisations (RTO) in the VET sector and smaller higher education institutions.

This work can leverage considerably off the AAF model and the work that has been undertaken by the MAMS project to develop the technical, business, legal and operational models that are required to provide a robust federated trust fabric.

Detailed recommendations as to how this should proceed are beyond the scope of this paper and have already been made in previous Education.au advice referred to above.

Recommendation 3: Develop an ongoing national collaborative capability to sustain and enhance the national software infrastructure in a rapidly changing technology environment.
The following capabilities are required to develop, operate and sustain the national software infrastructure:

- governance and strategy: policy, coordination and high level strategy
- operational Support including:
  - leadership in Interoperability standards
  - development and ongoing production operations of national shared systems
  - outreach in assisting stakeholders to enable their systems for interoperability
  - monitoring, tracking and trialling of emerging technologies to ensure the national infrastructure evolves to maintain relevance in a rapidly changing technical environment

There are cross-sectoral and sector-specific advisory and governance structures in place to coordinate the policy and strategy development aspects of building the national software infrastructure. Examples are AICTEC, NIDAAG and FLAG.

However, there is currently no ongoing operational support for the national software infrastructure.

A similar recommendation was made in the Croger Report (Interoperability Standards Across the Australian Education and Training Sector) on Interoperability Standards. This recommendation is repeated and expanded upon here because it is still a gap, still needs to be done and is the recommended vehicle to progress the previous recommendations.

Development and ongoing operations of national infrastructure services such as MAMS/AAF, edna, LORN, and The Learning Exchange has largely been achieved to date by national ICT-expert bodies such as Framework, MELCOE, education.au ltd and the Learning Federation. These organisations are well placed to continue to provide these types of national infrastructure services.

Much of the progress on interoperability standards to date has been achieved as an output from one-off projects and via the expertise of individual experts from groups such as MELCOE, Link Affiliates, Croger Associates, Education.au and the VET E-standards group. However, technology is constantly changing and an ongoing capability is required to ensure that the national software infrastructure continues to evolve to track new and emerging technologies.

The national software infrastructure provides interoperability services to interconnect the various e-learning systems that are (and will be) used by educators and learners. The return on investment of this infrastructure will depend on the extent to which these systems are enabled to access these interoperability services.

Some jurisdictions may choose to re-work existing systems or wait for new implementation projects to add access to the national interoperability services.

A key barrier to national interoperability for many jurisdictions is that often the expense and complexity of implementing to the required standards is difficult to cost-justify and resource on a per-project basis.

This is a particular problem for a number of smaller stakeholders within the education sector that lack the resources and technical expertise of the larger institutions to plug into national software infrastructure. These include independent schools, Catholic schools, ACE, early childhood, as well as smaller Registered Training Organisations (RTO) in the VET sector and smaller higher education institutions.
There is a key national role to provide supplementary resourcing (funds and expertise) to stakeholder when undertaking ICT projects to support the addition of this interoperability layer.

A national ongoing cross-sectoral capability is required to provide operational support to governance and advisory bodies. The role of this capability should be to:

- track, monitor and agree on interoperability standards in new and emerging areas
- facilitate agreement on relevant national interoperability standards
- work with other national and jurisdictional ICT initiatives to ensure that they are implemented in a manner that supports interoperability.
- advise on national interoperability issues and opportunities to extend existing systems to make them interoperable over the national infrastructure
- leverage leading institution developments nationally for the benefit of other stakeholders and other sectors of education
- facilitate, via partnerships with leading jurisdictions, pilots and trials to showcase interoperability in areas in which no well-established mature interoperability standards exist. facilitate knowledge transfer and best practice in the area of interoperability across all stakeholders in the education and training sector
- provide outreach and assistance for stakeholders to enable their systems for interoperability.
- track emerging technologies. Planning for continuous change by resourcing ongoing activities to look at new and emerging technologies with a view to maintaining the relevance and modern nature of the national infrastructure.

A key role of this capability will be to coordinate and facilitate the process on identifying, trialling, agreeing and implementing to open interoperability standard. Trials and piloting has already been recommended as the best way to progress priority issues such as:

- interoperability between social networking/collaborative systems
- interoperability between organisation-centric and person-centric approaches to identity, trust and access control

This ongoing capability should also be charged with facilitating, via partnerships with leading jurisdictions, trials and pilots to examine other emerging standards, needs and technologies including:

- ‘Cloud computing’ as 21st century infrastructure: investigating policy, quality of service and interoperability implications of integrating commercial Internet ‘cloud computing’ services into the national software infrastructure.
- Cross-sectoral approaches to secure data interchange: The currently SIF-based approach to secure data interchange services for schools needs to be extended to provide services for the other sectors.
- Seamless cross-sectoral resource discovery: More work needs to be done to provide more seamless national resource discovery and persistent identifier services for resources
- E-Portfolio interoperability. The companion SICTAS report on E-portfolios has identified the importance of an ongoing monitoring and tracking of standards for e-portfolio interoperability to ensure that lifelong learners in recording and using personal information throughout their working lives.
- Interoperability between virtual worlds and online conferencing systems
The expertise for this capability already exists within the education and training sector in jurisdictions, ministerial companies and expert consultants. It is recommended that this ongoing operational national cross-sectoral capability be devolved across these groups but with a single body having an overall collaboration, facilitation and coordination role.

The expected benefits of this investment in an ongoing support capability are:

- accelerating development of the next generation learner-centric national software infrastructure capabilities
- maximizing the nation’s return on investment in this infrastructure by facilitating take-up throughout all sectors of education for the benefit of all stakeholders
- maintaining the currency and relevance of the infrastructure in a rapidly changing technology environment.
This paper is one of a series commissioned by the Australian Government’s Department of Education, Employment and Workplace Relations (DEEWR) as part of the Strategic ICT Advisory Service project.

Its purpose is to investigate what is needed in terms of national software infrastructure to support 21st century learning. A particular emphasis of this investigation is the nature of software infrastructure that will be needed to support emerging Web 2.0 style learner-centric collaborative learning services.

4.1 Context and Rationale

The Australian Government has committed that the nation will have technology enriched learning environments. This is also a strategic recognition of the central role that technology plays in educating our citizens to become a digitally literate workforce.

Infrastructure, by definition, is the foundation that underlies an organisation or a system. It is comprised of the basic facilities, services and installations needed in order for those organisations or systems to function. To many, the term ‘infrastructure’ means roads, ports, power lines, water and sewage systems, but in 21st century Australia where a digital education revolution is underway, infrastructure that enables communications and other information technology for education is critical.

In recent years there have been a number of initiatives aimed at building an Australian national education sector software infrastructure, incorporating components of identity, trust, content, standards and infrastructure. This investigation focuses on issues around ongoing growth and development of Australia’s national software infrastructure, with a particular focus on software infrastructure for education.

The Australian Government’s National Broadband Network initiative represents a national strategic recognition of the central importance of the internet to the nation’s economic and cultural prosperity. It will be a key nation-building hardware ICT infrastructure project that will position this country well to compete in the 21st century digital online global economy.

The DER policy provides for the release of significant funds to further leverage the power of technology to improve teaching and learning. Key components of the DER strategy are to build up the nation’s hardware and software infrastructure to support and enable 21st century learning.

The internet is moving rapidly towards a ‘cloud computing’ model in which services are provided from the internet ‘cloud’ rather than from software on user’s computers or software provided by institutions. This model is driving the notion of the “personal web” and is challenging organisations to re-think the business effectiveness of in-house provided computing infrastructure.

These emerging internet models are key drivers for our understanding of what 21st century technology-enriched learning should look like. Two key characteristics discussed in this paper are the shift from an institution-centric towards a person-centric approach to the provision of e-learning services and closer integration with the learner’s existing online internet identity and services.

Today, students have an online identity, access to the latest online mobile devices and already participate online in a variety of formal and informal online networks, giving them access to global communities and resources and enhancing and enriching their daily living and their informal learning.
These students have an expectation that their formal learning experiences will be equally engaging, technically rich and relevant to their daily online lives.28

4.2 Target Audience

This investigation’s target audience is senior DEEWR policy advisors, and policy advisors in other Australian Government Departments with responsibilities around national software infrastructure. This investigation will assist its target audience by identifying actions that can be taken at a national level, while working within an environment made complex by the issues including Australia’s federated model of education and constant technological change.

4.3 Related Works

The SICTAS project has generated a number of reports relating to various aspects of ICT in education, and several more are pending. These reports interrelate, and there are especially strong links between this report and Collaboration in teaching and learning.29

4.4 Methodology

The investigation was conducted by desktop research and by consultation with experts involved in the SICTAS project and at Education.au more broadly. It was informed by the Education.au national ICT in Learning Symposium: Planning for Change.30

The following questions were investigated:

- What will 21st century learning look like and what types of ICT services will be required to support it? How do emerging internet trends like Web 2.0 and cloud computing impact on 21st century learning and software infrastructure?
- What is needed in terms of national software infrastructure to support 21st century learning and why? What should this 21st century software infrastructure look like?
- What parts of this infrastructure do we already have? What are the gaps and barriers? What still needs to be done? What processes to we need to support this infrastructure?
5 What a national 21st century software infrastructure would look like

This chapter explores what a national software infrastructure should look like to support 21st century technology-enriched learning.

The rationale for and likely characteristics of 21st century learning is discussed. Then the nature of infrastructure that would support this model of learning is described in terms of functionality and supporting processes.

Consideration is also given as to how this infrastructure should be deployed to best align with our federated model of education and with industry and technology trends.

5.1 Rationale and vision for 21st century learning

5.1.1 Technology-rich education

In 2008, the Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA) signed off on the Joint Ministerial Statement on Information and Communications Technologies in Australian Education and Training: 2008-2011, which was developed by AICTEC. The Ministerial Statement discusses the infrastructure requirements associated with the implementation of ICT across Australian education and training:

Technology rich learning environments will be underpinned by a secure and robust infrastructure, where software, computers and ICT equipment, networked systems, technical support and access to high speed broadband and online services will support educators in the delivery of world class education and training. Jurisdictional and cross sectoral access to networks and digital repositories of resources that are affordable, reusable, discoverable and shareable, will be supported by policy, sustainable resourcing and technical systems and standards that enable the building and exchange of knowledge and resources.

5.1.2 Aspirational Goals for ICT in education

The DER national vision for ICT in schools outlines a number of aspirational goals for preparing schools and the teaching workforce for 21st century learning. These include student-centric learning, access to contemporary resources, anytime anywhere access to courses and resources, student and teacher collaborative learning, and social networking.

This investigation notes the critical role of enabling software infrastructure in realising this vision.

A UK study on higher education in a Web 2.0 world confirmed the importance of engaging students with Web 2.0-style technology that is comparable to their online lifestyle. This paper also noted the critical role that national software infrastructure and recommended exploring ways to provide infrastructure that exploits Web 2.0 capabilities and models. Other studies in the USA have confirmed that Internet rich media and Web 2.0 applications are important tools for 21st century education.
A paper by leading industry provider CISCO articulated a global vision for equipping every learner for the 21st century. Central to this vision are the notions of the learner at the center, leveraging the internet as a tool for learning, and aligning learning with a learner's personal online world:

‘... the capacity for young people to complement their online social destinations – MySpace, Facebook and Second Life – with a personalized learning space.’

The University of California, Berkeley has developed a Collaborative Tools strategy in recognition of the importance of collaboration in learning, teaching and connecting with partners. A key component of this strategy is lowering barriers to collaboration by enhancing existing notions of institutional identity to support seamless integration with user-centric Web 2.0 notions of identity.

A paper by Education.au for the AESOC commissioned e-learning business model working group articulated a vision for e-learning to meet the needs of students, teachers and parents that involves a change of paradigm from the institution-centric to person-centric notions of e-learning service provision.

5.1.3 Internet as the driver of rapid technology change

The internet is moving rapidly towards a ‘cloud computing’ model in which services are provided from the internet ‘cloud’ rather than from software on users’ computers or software provided by institutions. This model is driving the notion of the “personal web” and is challenging organisations to re-think the business effectiveness of in-house provided computing infrastructure.

These emerging models of the internet and education are key drivers for our understanding of what 21st century technology-enriched learning should look like. Two key characteristics discussed in this paper are the shift from an institution-centric towards a person-centric approach to the provision of e-learning services and closer integration with the learner’s existing online internet identity and services.

Today, students have an online identity, access to the latest online mobile devices and already participate online in a variety of formal and informal online networks, giving them access to global communities and resources and enhancing and enriching their daily living and their informal learning. These students have an expectation that their formal learning experiences will be equally engaging, technically rich and relevant to their daily online lives.

5.1.4 Cloud computing as 21st century infrastructure

Internet cloud computing is challenging existing notions of how we build and deploy infrastructure and systems. It is likely that organisations will increasingly look to replacing in-house systems with services for the internet cloud now that mainstream vendors such as Google, Apple, Microsoft, Amazon, and IBM are now delivering their systems via this “software as a service” (SAAS) model.

The promise of more ready availability of high speed broadband network access is a key complementary enabler for cloud computing.

‘When the network becomes as fast as the processor, the computer hollows out and spreads across the network.’ Eric Schmidt. CEO, Google.

An Education.au paper recently published in the Education Technology Solutions journal concluded that cloud computing holds considerable promise of benefits not only for educators and learners but also for providers of ICT systems for education.
The confluence of cloud computing and high speed broadband is challenging the sustainability of 20th century approaches to ICT provision for teaching and learning that are based on in-house proprietary systems. The global technical and cultural phenomenon that is the internet, powered by a worldwide collaboration of the most brilliant and innovative ICT experts will continue to advance at a speed that no learning institution, nation or software vendor can hope to match.

The opportunity for the national software infrastructure to leverage internet cloud computing services is explored later in this section.

5.1.5 Collaborative learning

The SICTAS investigation, Collaboration in teaching and learning (CTL) provides several examples of how ICTs, particularly social networking software, benefits student learning:

- they encourage student engagement and increase participation, particularly among quieter students who can work collaboratively online without the anxiety of raising questions in front of a class of peers
- they enable expression through less traditional media such as video
- they extend learning opportunities by encouraging online discussion between students outside the physical bounds and working hours of the learning institution
- students feel a sense of ownership and engagement when they publish their work online, which can encourage attention to detail and improved quality of work overall

The national ICT in Learning Symposium: Planning for Change was hosted by Education.au in Sydney on 1 May 2009 as part of the SICTAS project. Sixty participants attended, including representatives from all education and training sectors, and from the technology industries. All states and territories were represented. There was significant discussion at the symposium around national infrastructure for education, and the summary below is from the communiqué disseminated after the symposium. It captures the current situation around national software infrastructure for education and key directions for policy ongoing.

Collaborative learning and connectedness are key characteristics of 21st century learning. It is important that infrastructure development – including physical infrastructure, software, standards and guidelines, and learning resources – leverages from the considerable achievements to date and is designed to continue to foster collaboration.

Appendix A contains a more detailed discussion of the background and rationale for national software infrastructure to support 21st century models of learning.

5.1.6 Key services to support 21st century learning

Government, researchers and industry are aligning in a shared vision for 21st century technology enriched learning and the role of software infrastructure:

- An education ‘cloud’ - Learners connected 24x7 to their online learning ‘cloud’ via high speed broadband and wireless networks using models similar to Web 2.0 and the Internet cloud computing.
- Collaborative learning - Educators and learners engaging in collaborative learning activities across jurisdictional and geographic boundaries seamlessly, safely and securely.
- Seamless resource discovery - Learners accessing learning services and resources from multiple learning providers, nationally and internationally.
- Learner-centric identity - integrating a learner's jurisdiction and personal internet identities to support life-long learner transition from primary school to secondary school to vocational education and training or university to the workforce.

A national software infrastructure supports collaborative learning via access to e-learning services that are readily accessible, intuitive and integrated in a way which makes them easy to use.

These services provide safe places to interact with other learners across Australia, to undertake course work both within and across institutions, and to explore career options and to develop e-portfolios comprising content aggregated from a range of sources.

Learners can gain access to educational programs beyond the limitations of the local environment, particularly in the case of students in remote locations or in the case of the delivery of courses such as Asian language study for which teachers and lecturers are scarce.

Educators in all education institutions can gain access to an up-to-date range of content linked to the curriculum, collaborate with colleagues across a range of jurisdictions, and maintain their own professional e-portfolio comprising content aggregated from a range of sources.

The infrastructure provides the national plumbing to interconnect institutional services and systems with seamless 'back end' functionality largely invisible to the end user teacher or learner. It renders the distinction between national versus institutional delivery sources largely irrelevant.

Educators and learners are able to integrate their institutional and internet/Web 2.0 identities and seamlessly access resources and collaboration networks that span both the institutional and internet/Web 2.0 worlds.
5.2 Context: Where national software infrastructure fits in

Figure 1 below illustrates how a national software infrastructure fits within the broader Australian education context.

**Figure 1: National software infrastructure context**

- **Schools**
  - Government
  - Catholic
  - Independent

- **VET**
  - TAFEs
  - Private RTOs

- **Higher Education**

- **Other**
  - Early childhood
  - ACE
  - Education organisations

**People**
- learners
- educators
- parents
- researchers
- industry

**...accessing Services and content...**
- resource discovery
- national collaboration
- e-portfolios
- assessment and reporting
- safe, quality assured content

**...enabled by National software infrastructure...**
- governance and leadership
- interoperability standards
- education ‘cloud’
- secure data interchange
- seamless resource discovery
- collaborative learning
- learner-centric identity

**...delivered via National physical infrastructure**
- national broadband network
- learning devices and learning spaces
Figure 1 depicts groups of people across all sectors of education accessing content and learning services (applications) that are enabled and support by a national software infrastructure. The software infrastructure itself is delivered via a national hardware infrastructure that includes high speed broadband.

Key roles for the national software infrastructure are:

- providing services that are common to all applications, including identity, authentication, access control and data interchange
- supporting interoperability between systems
- providing services across all sectors and jurisdictions.

5.3 Functionality: What infrastructure services should be provided

NIDAAG has identified a number of key priority areas for the national software infrastructure:

- 21st century learning and teaching
- content management
- interoperability of systems and data
- identity and access management
- shared use of infrastructure.

These category areas provide a sound basis on which to articulate the functional scope of the national software infrastructure.

This paper discusses under these broad NIDAAG functional areas what types of infrastructure services will be required to support and enable the vision for 21st century learning described previously.

A key focus of this discussion is ensuring provision for both learner-centric and institution-centric services and seamlessly integration with internet ‘cloud’ services and learners’ personal Web 2.0 world.

The first NIDAAG priority area (21st century learning and teaching) aligns most closely with the scope of this paper. However, a number of the other priority areas are also discussed as they also provide key supporting infrastructure that is required to deliver 21st century learning services.

5.3.1 21st century learning and teaching: support for collaborative learning

NIDAAG priority areas that relate to collaborative learning include services for Web 2.0 social networking, virtual worlds and virtual classrooms.

There is a key role for a national software infrastructure to support:

- secure and safe networks across jurisdictions to facilitate collaboration for both student learning and teacher professional learning
- collaborative interoperability, and support to allow various jurisdictional collaborative environments to interoperate via standards.
5.3.2 Content management: support for seamless resource discovery

NIDAAG priority infrastructure areas that relate to content include services for sharing, discovery, access and persistent identifiers.

National software infrastructure services are required to support:

- a one-stop-shop approach to discovery of resources that are dispersed across jurisdictions, provided by various external resource providers and available on the internet ‘cloud’
- services to ensure that teachers and learners can find resources that are relevant to their educational activities. In the schools sector this would include standard ways to link content to national curriculum areas. In the VET sector it would require linking content to competency areas. These ways should include more than just static metadata tagging and extend to supporting Web 2.0 modes where educators and learners can find content based on their peers’ recommendations and comments.

5.3.3 Interoperability of systems and data: support for secure data interchange

A key opportunity for a national software infrastructure service is support for a secure data interchange mechanism to support national assessment and reporting data flows across jurisdictions and aggregation to the national level.

This has been identified by NIDAAG, the LIMF report and the Croger Report as a key strategic requirement.

5.3.4 Identity and access management: support for learner-centric identity

Trust, identity and access control are key underpinning infrastructures that provide a secure platform for all the services mentioned above. These national capabilities have also been identified by NIDAAG, the LIMF report and the Croger Report as key strategic requirements.

This security infrastructure will enable:

- learners and educators to collaborate safely and securely with their peers across geographic, jurisdictional and sector boundaries
- learners and educators to collaborate more easily with colleagues because it is easier to share access to tools and resources
- easier access to national services as users need to remember only one account from their own institution instead of requesting and remembering accounts from several different resource providers.
- resource providers to provide access to their resources or services to authorised users in a secure way without having to issue or manage user accounts.

A key requirement to support learner-centric 21st century services will be the capability of this infrastructure to allow learners and educators to seamlessly integrate their institution and personal Web identities.
5.3.5 Shared use of infrastructure: support for an education ‘cloud’

NIDAAG priorities in this area include shared infrastructures and networks to support 21st century learning.

The internet is moving rapidly towards a ‘cloud computing’ model in which services are provided from the Internet ‘cloud’ rather than from software on users’ computers or software provided by institutions. This model is driving the notion of the ‘personal web’ and is challenging organisations to re-think the business effectiveness of in-house provided computing infrastructure.

The NSW education department is already moving to integrate internet cloud computing services from Google with its internal infrastructure. Integrated repository services such as iTunes U are already in widespread usage within the higher education sector. It is likely that this service will also be adopted by other sectors as well.

The cloud computing approach used by Google, Apple and others demonstrates the power of standards-based integrated services run from the internet cloud. It also shows the potential to provide multiple integrated and expandable services from such platforms.

There are still a number of issues to be resolved with internet ‘cloud’ services before there is widespread adoption into the national infrastructure. These issues include:

- guarantees of service availability
- interoperability and transferability of data
- privacy and intellectual property.

Despite these issues, this ‘cloud computing’ model appears to offer a compelling strategic opportunity for the Australian education sectors. It is likely that software infrastructure in the education sector will increasingly involve the cost-effective leveraging of selected internet ‘cloud computing’ services to support collaborative teaching and learning with the following potential benefits:

- educators and learners can connect with the online world anytime, anywhere
- learners access this infrastructure via their own learning devices: laptops, iPhones and mobile devices that have not yet even been invented (future proof)
- user-centric approach to services. The person-centric nature of ‘cloud computing’ supports the concept of learners accessing learning services and resources from multiple learning providers, nationally and internationally. As a learner transitions from primary school to secondary school to vocational education and training or higher education and to the workforce, she remains in full control of her digital identity and footprint. This identity and footprint is distributed across all her learning providers past and present as well as all the other internet services she has consumed.
- digital literacy. Learners enter the workforce as internet-savvy, capable of using the power of the internet in their work and also for ongoing life-long learning. Every Australian’s learning journey equips them with the digital literacy skills they need to contribute to the modern online global economy.
- cost effective infrastructure: In this model, the internet comprises much of our national e-learning infrastructure. It is always modern as new advances are instantly available to all teachers and learners. It is always relevant and engaging to learners at all stages of life.
5.4 Interoperability standards and emerging technologies

Interoperability standards are a key and necessary component of the national software infrastructure. This importance has been long recognised and endorsed by NIDAAG, the LIMF report and the Croger Report.

Ongoing processes to collaboratively agree on national interoperability standards will be essential to ensure that the national software infrastructure is cost-effective, extensible and future-proof.

ICT and the internet continue to be a global phenomenon of rapid technology innovation and advancement.

The national software infrastructure will need to be supported by ongoing processes to:

- track, monitor and agree on interoperability standards in new and emerging areas
- facilitate agreement on relevant national interoperability standards
- work with other national and jurisdictional ICT initiatives to ensure that they are implemented in a manner that supports interoperability
- advise on national interoperability issues and opportunities to extend existing systems to make them interoperable over the national infrastructure
- leverage leading institution developments nationally for the benefit of other stakeholders
- conduct pilots and trials to showcase interoperability in areas in which no well-established mature interoperability standards exist
- facilitate knowledge transfer and best practice in the area of interoperability across all stakeholders in the education and training sector
- track emerging technologies, and plan for continuous change by resourcing ongoing activities to look at new and emerging technologies with a view to maintaining the relevance and modern nature of the national infrastructure.

5.5 Governance

Governance, leadership and operations are required to ensure that the national infrastructure is developed, sustained and enhanced to keep pace with rapidly changing technology.

The federated nature of education in Australia presents a number of challenges for policy makers in deciding how best to spend funds to get the best return on investment in ICT in education. For many, the notion of infrastructure conjures up visions of centralised national systems. This notion does not align well with Australia’s federated model of government. In the national context, state and territory jurisdictions operate locally as well as collaborate nationally. Significant investments have been made at the institutional level. Any strategy for a national software infrastructure needs to be inclusive of this reality by:

- facilitating a shared understanding by all stakeholders of software infrastructure and how it can be implemented in a way that aligns with and supports Australia’s federated education model
- facilitating a national collaboration to promote and support standards-based interoperability between jurisdictional systems
• providing ways to lower the barrier of entry especially for smaller education and training stakeholders (Catholic schools, Independent schools, RTO’s, early childhood) that may lack the ICT resources of the larger institutions

• promoting a partnership approach that enables the innovative advances made by leading jurisdictions and education technology companies to be easily and quickly leveraged across other jurisdictions.

5.6 Deployment

For many, ‘infrastructure’ suggests connotations of centralised national systems which do not align well with our federated model of government. The proposed deployment model for the national software infrastructure is primarily one of devolved systems implemented and managed by the institutions and internet ‘cloud computing’ providers, interoperating nationally via agreed national standards. There will be some elements of the national infrastructure that will need to operate as a single central shared service. These will need to be operated by a national body on behalf of all stakeholders. Examples include:

• national SIF-based data interchange will require a central hub server to interconnect the various jurisdictional systems

• a national persistent identifier service may best be implemented as a central system

• a national trust federation will require some shared infrastructure to interconnect the various jurisdictional Identity and service provider systems and provide interoperability between these organisation-centric systems and Web 2.0-style person-centric technologies such as OpenID.

The proposed model for the national software infrastructure is an Australian education sector cloud supporting the connection and interoperability of systems and a diverse range of implementation approaches including:

• national centralised systems

• local jurisdictional systems

• internet ‘cloud computing’ services

• interoperability between these systems via agreed national standards.

5.7 Summary

Technology enriched 21st century learning is characterised by 24x7 connection to learning resources and seamless, secure collaborative learning activities across jurisdictional and geographic boundaries.

In order to provide this technology enriched national learning capability an approach to national software infrastructure that supports 21st century learning is required. This infrastructure should be focused on enabling services to meet learner needs. It should deliver learner-centric services seamlessly across geographic, jurisdictional and sectoral boundaries.

The infrastructure should be based on a nationally agreed set of interoperability standards and governance, leadership and operational processes to ensure that the national infrastructure is developed, sustained and enhanced to keep pace with rapidly changing technology.
6 What has been done and what still needs to be done

This chapter compares what has been achieved so far in the developing the national software infrastructure with the vision developed in the previous section to identify what still needs to be done.

A full analysis of all areas of software infrastructure is a large undertaking and beyond the scope of this paper which is restricted to identifying the nature of software infrastructure that will be needed to support emerging Internet ‘cloud computing’ models and Web 2.0 style learner-centric collaborative learning services.

There has already been considerable progress made towards building the national software infrastructure. Key initiatives have included edna,\textsuperscript{63} the Australian Access Federation (AAF),\textsuperscript{64} the Learner Identity Management Framework (LIMF),\textsuperscript{65} LORN,\textsuperscript{66} Australian Research Repositories Online to the World (ARROW),\textsuperscript{67} Persistent Identifiers (PILIN),\textsuperscript{68} and the Schools Interoperability Framework (SIF).\textsuperscript{69}

More details about work that has been achieved in Australia and internationally in terms of software infrastructure for education can be found in Appendix B.

Today we have national software infrastructure that incorporates elements of identity, secure access, content and interoperability standards. Much of this infrastructure is specific to an individual sector and is institution-centric in nature. Examples include:

- Australian Flexible Learning Framework\textsuperscript{70} initiatives such as the Learning Object Repository network (LORN),\textsuperscript{71} and E-standards\textsuperscript{72} in the VET sector
- Australian Research Repositories Online to the World (ARROW),\textsuperscript{73} focused on support interoperability of institutional repositories for the higher education sector
- The SIF\textsuperscript{74} project will interconnect institutional administration systems in the school sector
- The MAMS\textsuperscript{75} and AAF\textsuperscript{76} projects, which have delivered institutional identity and access control infrastructure in the higher education sector.

These initiatives have all contributed to necessary and fundamental underpinning infrastructure to support the business of education.

However, to support technology-rich 21st century modes of learning the institution-centric nature of existing national software services needs to be complemented and extended by a set of services that are focused on learners and educators, are user-centric in nature and are modelled on and seamlessly integrated with modern Web 2.0 and cloud services. These learner-centric services can be thought of as an education cloud: a user-centric set of services based on the internet cloud computing model that supports anywhere, anytime access to learning across geographic, jurisdiction and sector boundaries.

Figure 2 below provides a high level overview of the key differences between the functionality enabled by the current environment and the types of scenarios enabled by the aspirational 21st century infrastructure model across three key service areas:

- identity and access
• collaborative learning
• resource discovery.

Figure 2: Comparison of current and aspirational functionality

<table>
<thead>
<tr>
<th>Service</th>
<th>Current</th>
<th>Vision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identity and Access</td>
<td>Institutions provide learners with an identity for the duration of their tenure. When the learner transitions, her identity and digital footprint at that institution is largely no longer accessible to her. Much of a learner’s online digital identity and footprint on the internet is blocked while they are within the learning institution. The learner is supplied with locked-down ICT devices that are technically inferior to her own personal ICT devices.</td>
<td>Learners have and are in control of their own internet-based digital identity and footprint. Learning providers (eg institutions) provide learning services and link into the learner’s identity. Learners have full access to their own online digital identity and footprint in addition to services provided by their learning institution. The learner accesses these services by her own personal ICT devices.</td>
</tr>
<tr>
<td>Collaborative Learning</td>
<td>Institutions provide environments for students and teachers to collaborate within that institution.</td>
<td>Learners and teachers collaborate safely and securely with their peers seamlessly across geographic, jurisdictional and sector boundaries.</td>
</tr>
<tr>
<td>Resource Discovery</td>
<td>Institutions provide selected learning resources via in-house proprietary repositories. Learners have little visibility of resources that are held within other institutions.</td>
<td>Learners across all jurisdictions and sectors and in the workforce have access to resources from a vast range of internet repositories and cloud computing services nationally and internationally. Learners use their online social networks to find the most relevant resources that have been recommended to them by their peers and teachers.</td>
</tr>
</tbody>
</table>

This section now discusses how to overcome these gaps in more detail. The focus is on software infrastructure work that needs to be done to support emerging internet cloud computing models and Web 2.0 style learner-centric collaborative learning and resource discovery. Consideration is also given to the supporting processes that will be required to develop, support, and maintain this infrastructure.

Other complementary infrastructure components; for example, those that relate to secure data interchange between institutional systems, are mentioned for completeness but not detailed.

The gap between the current (including and work underway in areas such as data interchange) and desired software infrastructures is depicted conceptually in the following two models.
Figure 3 depicts the institution-centric nature of the current infrastructure environment:

- The infrastructure supports back end interoperability between jurisdictional systems for the purposes of federated access control, repository interoperability and data interchange.
- Collaboration is supported within jurisdictions. There is no infrastructure support for collaboration across jurisdictions.
- A learner’s identity and access is authenticated and managed by the institution. There is no infrastructure support to integrate this identity with the learners’ internet identity and environment.

Figure 4 depicts this institution-centric infrastructure environment enhanced with additional learner-centric services to support collaborative interoperability and integration with internet services:

- A learner’s identity and access is still authenticated and managed by the institution. There is infrastructure support to integrate this identity with the learners’ Internet identity and environment.
- Secure, safe collaboration is supported seamlessly within and across jurisdictions.
Figure 3: Current national software infrastructure

Figure 4: Desired National Software Infrastructure
6.1 Trust, Identity and Access: Support for Learner-centric Identity

The MAMS project demonstrated a trust federation business model and Shibboleth technology to create a national trust fabric for the Australian higher education sector by interconnecting the various institutional identity management systems to provide strong levels of authentication and access control across jurisdictional boundaries. Considerable work has been undertaken to develop the business, legal and operational models that are required to provide a robust federated trust fabric across the higher education sector. This work led to the formation of the AAF for higher education.

The suitability of the higher education trust fabric for the school and VET sectors has been reviewed. This has revealed that in recent years new Web 2.0 approaches to identity and trust have emerged, the most notable being OpenID\textsuperscript{77} and Identity Meta-system\textsuperscript{78 79} approaches and Information Cards.\textsuperscript{80}

OpenID is a light-weight, user-friendly Web 2.0 open standard that supports a user-centric approach to digital identity, single sign-on and access control. It is supported by Google, Facebook, MySpace, Twitter, Yahoo and many other popular Web 2.0 sites. The self-asserted nature of most OpenID implementations has led to questions as to whether OpenID provides the necessary levels of trust for safe, secure collaboration within the education sector.

Information Cards represent an easy to use person-centric approach to online digital identities using the visual metaphor of a wallet with a set of cards each representing an identity.

The concept of an identity meta-system, an interoperable architecture for digital identity that enables users to manage and integrate multiple digital identities across multiple underlying technologies, holds considerable promise for the education sector.

Some progress has been made in this area in the school and VETs these sectors:

- There has been interest by some state school jurisdictions and Catholic schools in looking at implementing the key AAF Shibboleth technology.
- The VET sector LORN project is looking at a trust fabric to provide authenticated access to commercial learning objects within the VET sector.
- The school sector Scootle system has investigated OpenID technology as a light-weight approach to authentication.

Education.au has previously provided advice\textsuperscript{61} to the Australian Government about extending the concept of the higher education sector AAF into a trust federation for the VET and schools sector.

Much of this previous advice is supported here as this investigation has determined that a whole-of-education-sector trust fabric is a fundamental enabling platform essential to delivery of effective 21\textsuperscript{st} century learning services allowing learners and educators to connect securely and safely to their peers and resources across geographic, jurisdiction and sector boundaries.

While Web 2.0 social networking sites, technologies and standards provide rich opportunities for collaborative learning they currently do not provide the robust authenticated models for identity and trust that will be required to support collaborative learning and other services in education.

Learning institutions, through their internal enrolment processes and identity management systems, can provide this high level of authentication about identity and roles for learners and educators.

It is timely to re-investigate the best technical approaches to providing this trust fabric with a view to determining how to leverage the ease of use and global reach of Web 2.0 approaches while
supporting the high levels of authentication and trust that exists within institutional identity management processes and systems.

Although the technologies and standards for both institutional identity management and Web 2.0 style user-centric services are both robust and mature, the methods of integrating these two models are not yet well known or proven. So much of the early work in building this integrated infrastructure will involve pilots and trials.

Pilots and trials should be resourced involving all three sectors of education to look at ways to extend the work done by the MAMS project in terms of Shibboleth-based organisation-centric approaches to trust networks to include interoperability with Internet Web 2.0-style person-centric identity and access services such as OpenID and emerging identity meta-system approaches.

The objectives of these trials would be to:

- obtain and independent expert review of technical options including shibboleth, OpenID and meta-identity approaches
- trial a Web 2.0 user-centric approach to identity management and access control using Web 2.0 technologies such as OpenID and Identity Meta-system approaches such as Information Card
- investigate opportunities for interoperability between these user-centric Web 2.0 and the institution-centric Shibboleth approaches to identity and access control
- demonstrate how this infrastructure can be used to support secure, user-centric collaborative learning applications that cross institutional and sector boundaries.

Example applications could include connecting social networking systems for collaborative student learning and educator professional learning, access to directories of educators and a system for educators to share and recommend resources.

These activities should involve collaboration with leading experts from within the education and training sector as well as industry.

A key objective of these trials is to prove and develop learner-centric digital identity services that integrate institution-centric identity services with Web 2.0 identity services to enable learners to seamlessly integrate their institutional and personal Internet identities in a secure manner.

Once the technical approaches to creating secure learner-centric services for identity and access have been agreed, the next steps are to establish the appropriate legal and operational elements of the national trust fabric and facilitate take-up of this service by all stakeholders including:

- state and territory school jurisdictions
- Catholic schools
- independent schools
- TAFEs
- smaller stakeholders such as ACE, early childhood, as well as smaller Registered Training Organisations (RTO) in the VET sector and smaller higher education institutions.

This work can leverage considerably off the AAF model and the work that has been undertaken by the MAMS project to develop the technical, business, legal and operational models that are required to provide a robust federated trust fabric.
Detailed recommendations as to how this should proceed are beyond the scope of this paper and have already been made in previous Education.au advice, referred to above.

A key barrier to take-up of this trust infrastructure for smaller stakeholders and independent schools is that they lack the resources and technical expertise of the larger institutions. There is a role for a national body to act as an intermediary to provide these services on behalf of this group of stakeholders.

Recommendation 2: Develop a national cross-sectoral trust fabric to support secure learner-centric identity and access management.

6.2 Support for collaborative learning

Education.au’s me.edu.au service (also available as a standalone tool known as FusED) provides a national Web 2.0-style ‘Facebook for educators’ service. This is a particularly valuable way to allow educators to connect and collaborate across jurisdictional and sector boundaries and provides support for many smaller stakeholders that are outside the mainstream large state-based jurisdictions.

Jurisdictions are also beginning to implement Web 2.0 style collaborative, social networking environments to support teacher professional learning and student collaborative learning. However, these implementations largely only allow collaboration within jurisdictional boundaries.

Internationally work in this area includes the SocialLearn project at the OpenUniversity in the UK aimed at providing a distributed social network for learners. The popular open source SAKAI learning management tool is being re-engineered to support Web 2.0 Open Stack standards for distributed collaborative learning. Emerging innovative distributed collaborative environments such as Google Wave are also based on these Open Stack standards.

Work needs to be done to agree on standards for inter-connecting collaborative (social networking) environments to enable true national secure collaboration across jurisdictional and sectoral boundaries.

Pilots and trials should be commenced to determine the appropriate standards and technologies to support interoperability of collaborative environments across jurisdictional and sectoral boundaries. Key candidate technologies and open standards are those often referred to as the ‘Open Stack’ and in common use in popular Web 2.0 social networking sites:

- OpenID
- XRDS-Simple
- OAuth
- PortableContacts
- OpenSocial

This collaborative infrastructure must also be secured via integration with the national trust infrastructure. The challenges here are similar to those mentioned above in relation to integrating identity and access control models. Although the technologies and standards for both these institutional and Web 2.0 style user-centric services are both robust and mature, the methods of integrating these two models are not yet well known or proven. Much of the early work in building this integrated infrastructure will involve pilots and trials.
Work is already underway in this area. Trialling is commencing with the education.au and the NSW VET sector implementing an in-house version of the FusED social networking tool.

It is recommended that that this trialling be extended to cover a number of jurisdictions across the sectors and to include aspects of interoperability between different implementations of the product. The trial should include social networking tools (such as FusED) that are already based on some Open Stack standards, easily extensible to the full Open Stack suite and customisable for integration with other elements of the national software infrastructure such as trust fabric technologies. This trial would be used to achieve a number of objectives:

- provide a tool for educators to collaborate for professional learning and peer support
- demonstrate the use of Web 2.0 tools for teaching and learning
- demonstrate standards-based interoperability between devolved collaborative tool implementations
- demonstrate the integration of Web 2.0 user-centric Open Stack standards with the AAF-based Shibboleth Authentication and access control to support safe, secure collaboration.

Recommendation 1: Add support for learner-centric identity and collaboration services to the existing national software infrastructure.

6.3 Support for seamless resource discovery

Resource interoperability is the most fully implemented component of the national software infrastructure model.

Key initiatives in this area have included edna, LORN, Australian Research Repositories Online to the World (ARROW), Persistent Identifiers (PILIN), the Learning Exchange and Scootle.

Many of these initiatives have been specific to a single sector.

More needs to be done to provide seamless national resource discovery and persistent identifier services for resources. The details of this work are outside the scope of this paper.

A key requirement here is to integrate notions of resource discovery, collaborative learning and trust fabrics to enable learners use their secure online social networks to find the most relevant resources that have been recommended to them by their peer and teachers.

Another requirement is for a national approach to relating resources to the national curricula via a combination of metadata tagging and Web 2.0-style social networking.

Recommendation 1: Add support for learner-centric identity and collaboration services to the existing national software infrastructure.

6.4 Support for secure data interchange

The recently formed SIF-AU function is progressing work on establishing a national SIF service to support SIF-based secure data interchange in the schools sector.

The currently SIF-based approach to secure data interchange services for schools needs to be extended to provide services for the other sectors. The details of this work are outside the scope of this paper.
6.5 Governance, strategy, standards and operational support

The following capabilities are required to develop, operate and sustain the national software infrastructure:

- governance and strategy: policy, coordination and high level strategy
- operational support including:
  - leadership in Interoperability standards
  - development and ongoing production operations of national shared systems
  - outreach in assisting stakeholders to enable their systems for interoperability
  - monitoring, tracking and trialling of emerging technologies to ensure the national infrastructure evolves to maintain relevance in a rapidly changing technical environment.

There are cross-sectoral and sector-specific advisory and governance structures in place to coordinate the policy and strategy development aspects of building the national software infrastructure. Examples are AICTEC, NIDAAG and FLAG.

However, there is currently no ongoing operational support for the national software infrastructure.

A similar recommendation was made in the Croger Report on Interoperability Standards. This recommendation is repeated and expanded upon here because it is still a gap, the work still needs to be done, and an ongoing national collaborative capability is required to progress Recommendation 1.

Development and ongoing operations of national infrastructure services such as MAMS/AAF, edna, LORN, and The Learning Exchange has largely been achieved to date by national ICT-expert bodies such as MELCOE, Education.au and the Le@rning Federation. These organisations are well placed to continue to provide these types of national infrastructure services.

Much of the progress on interoperability standards to date has been achieved as an output from one-off projects and via the expertise of individual experts from groups such as MELCOE, Link Affiliates, Croger Associates, Education.au and the VET E-standards group. However, technology is constantly changing and an ongoing capability is required to ensure that the national software infrastructure continues to evolve to track new and emerging technologies.

The national software infrastructure provides interoperability services to interconnect the various e-learning systems that are (and will be) used by educators and learners. The return on investment of this infrastructure will depend on the extent to which these systems are enabled to access these interoperability services.

Some jurisdictions may choose to re-work existing systems or wait for new implementation projects to add access to the national interoperability services.

A key barrier to national interoperability for many jurisdictions is that often the expense and complexity of implementing to the required standards is difficult to cost-justify and resource on a per-project basis.

This is a particular problem for a number of smaller stakeholders within the education sector that lack the resources and technical expertise of the larger institutions to plug into national software infrastructure. These include independent schools, Catholic schools, ACE, early childhood, as well as smaller RTOs in the VET sector and smaller higher education institutions.
There is a key national role to provide supplementary resourcing (funds and expertise) to stakeholders when undertaking ICT projects to support the addition of this interoperability layer.

A national ongoing cross-sectoral capability is required to provide operational support to governance and advisory bodies. The role of this capability should be to:

- track, monitor and agree on interoperability standards in new and emerging areas
- facilitate agreement on relevant national interoperability standards
- work with other national and jurisdictional ICT initiatives to ensure that they are implemented in a manner that supports interoperability
- advise on national interoperability issues and opportunities to extend existing systems to make them interoperable over the national infrastructure
- leverage leading institution developments nationally for the benefit of other stakeholders
- facilitate pilots and trials via partnerships with leading jurisdictions to showcase interoperability in areas in which no well-established mature interoperability standards exist
- facilitate knowledge transfer and best practice in the area of interoperability across all stakeholders in the education and training sector
- provide outreach and assistance for stakeholders to enable their systems for interoperability
- track emerging technologies
- plan for continuous change by resourcing ongoing activities to look at new and emerging technologies with a view to maintaining the relevance and modern nature of the national infrastructure.

A key role of this capability will be to coordinate and facilitate the process of identifying, trialling, reaching agreement on, and implementing to open interoperability standard. Trials and piloting has already been recommended as the best way to progress priority issues such as:

- interoperability between social networking/collaborative systems
- interoperability between organisation-centric and person-centric approaches to identity, trust and access control.

This ongoing capability should also be charged with facilitating trials and pilots, via partnerships with leading jurisdictions, to examine other emerging standards, needs and technologies including:

- cloud computing as 21st century infrastructure
  - investigating policy, quality of service and interoperability implications of integrating commercial internet cloud computing services into the national software infrastructure
- cross-sectoral approaches to secure data interchange
  - the currently SIF-based approach to secure data interchange services for schools needs to be extended to provide services for the other sectors.
- seamless cross-sectoral resource discovery
  - more work needs to be done to provide more seamless national resource discovery and persistent identifier services for resources.
- e-portfolio interoperability
  - the companion SICTAS report *E-portfolios beyond education and training* has identified the importance of an ongoing monitoring and tracking of standards for e-
portfolio interoperability to ensure that lifelong learners can record and use personal information throughout their working lives.

- interoperability between virtual worlds and online conferencing systems.

The expertise for this capability already exists within the education and training sector in jurisdictions, ministerial companies and expert consultants. It is recommended that this ongoing operational national cross-sectoral capability be devolved across these groups but with a single body having an overall collaboration, facilitation and coordination role.

The expected benefits of this investment in an ongoing support capability are:

- accelerating development of the next generation learner-centric national software infrastructure capabilities
- maximizing the nation’s return on investment in this infrastructure by facilitating take-up throughout all sectors of education for the benefit of all stakeholders
- maintaining the currency and relevance of the infrastructure in a rapidly changing technology environment.

Recommendation 3: Develop an ongoing national collaborative capability to sustain and enhance the national software infrastructure in a rapidly changing technology environment.

6.6 Suggested key priorities for 2009-2011

It is most likely that the first activities to be undertaken that would support the development of 21st century national software infrastructure for education and training will be services such as collaboration functionalities for the literacy and numeracy national partnerships.

Other worthwhile projects could include retro-fitted existing national services such as myfuture,102 me.edu.au103 and edna104 to support national interoperability standards.

It is not realistic for institutions to immediately reinvent their existing systems to become compatible with the new national infrastructure, but once that infrastructure is defined, over time these major systems will move to compatibility as they are updated, enhanced or replaced.

Funding initiatives such as DER can be the vehicles to progress the following projects that are necessary building blocks for the national infrastructure. Some of these initiatives are already underway:

- national approaches to identity, trust and access control integrating intuition-centric and web 2.0-style person-centric approaches and technologies
- national approach to interoperability of collaborative environments
- national approach to seamless resource discovery
- national approach to relating resources to the new national curriculum via a combination of metadata tagging and social networking
- issues associated with cloud computing software infrastructure services
- sandpit spaces for trial and evaluation of new technologies and testing interoperability
- trialling e-portfolio interoperability services
- investigating national cross-sectoral approaches to secure data interchange.
6.7 Summary

There has already been considerable progress made towards building a national software infrastructure that incorporates elements of identity, secure access, content discovery and interoperability standards but these elements are mostly specific to an individual sector and are institution-centric in nature.

The next key step forward is the enhancement of existing investments in national education software infrastructure to support seamless integration with emerging Internet cloud computing models and closer integration with the learner’s existing online Internet identity and services.

Adding support to existing advisory bodies with an ongoing operational capability in areas such as interoperability standards, tracking of emerging technologies, facilitation and outreach will accelerate development and help to sustain and maintain the infrastructure in a rapidly changing technical environment.
7 Conclusion

This paper proposes an Australian national software infrastructure for education and training that will accelerate and enable the Government’s vision for 21st century learning in a way that aligns with Australia’s federated political model.

A particular emphasis of this investigation is the nature of software infrastructure that will be needed to support emerging internet ‘cloud computing’ models and Web 2.0 style learner-centric collaborative learning services.

Australia is well positioned to be a leader in the provision of technology enriched education. We are already well advanced in the provision of much of the required underpinning national infrastructure that will be required to support 21st century learning. Today we have national software infrastructure that incorporates elements of identity, secure access, content and interoperability standards, but these elements are mostly specific to an individual sector and are institution-centric in nature.

The next key step forward is the enhancement of existing investments in national education software infrastructure to also support person-centric learning services via:

- seamless cross-sector services
- integration with emerging internet ‘cloud computing’ models
- integration with the learner’s institutional and online Internet identity and services.

This will enable and drive our national capability to provide 21st century technology-enriched learner-centric services such as safe, secure collaborative learning seamlessly across geographic, jurisdiction and sector boundaries.

Adding support to existing advisory bodies with an ongoing operational capability in areas such as interoperability standards, tracking of emerging technologies, facilitation and outreach will accelerate development and help to sustain and maintain the infrastructure in a rapidly changing technical environment.

An important physical characteristic of this proposed software infrastructure is its devolved nature in terms of system deployment. It will comprise largely of a network of stakeholder systems and internet ‘cloud computing’ services interoperating via agreed standards with only a minimal set of centrally operated shared services.

Similarly, the expertise and capability to develop the required interoperability standards and processes is largely devolved to the stakeholders.

The national role for developing, maintain and renewing this national software infrastructure will be more about facilitation, collaboration and coordination than centralising systems and expertise.
8 Appendix A: Drivers for 21st century software infrastructure

This chapter presents a discussion of the various drivers that provide impetus for national software infrastructure initiatives. Three classes of drivers are explored:

- the 21st century learning agenda
- policy drivers, including equity and social inclusion, innovation, and Australia’s productivity agenda
- technology drivers, including emerging technologies and best practice procurement considerations.

The national curriculum is also briefly discussed, an example of both a 21st century learning driver and a policy driver. An interconnecting web of policy initiatives is observed.

8.1 Why: collaboration and person-centric services are key new drivers for national software infrastructure

Much of the focus for national software infrastructure activities in Australian education has been to support resource creation and discovery and metadata interoperability. For example, the ARROW project in the higher education sector looked at repository integration via metadata harvesting. The LORN project in the VET sector developed a national repository interoperability and resource discovery capability. The TLF and Scootle projects developed centralised systems for resource creation, repository management and access across the schools sector.

The AAF initiative to build a national trust federation for the higher education sector is primarily predicated on supporting secure access to protected high value resources such as research facilities and commercial publication catalogues. Of course the AAF trust federation is capable of supporting a wide range of needs relating to identity, security and access control. The schools and VET sectors have expressed interest in the AAF capability. But, to date, progress has been slow primarily due to less pressing needs in these sectors for highly secure access to high value resources.

The previous chapter has shown that a key emerging business driver for national education software infrastructure is supporting seamless, secure collaboration across jurisdiction and sector boundaries. This will require national cross-sectoral agreements on interoperability approaches and standards to interconnect collaboration systems. It will also require an underpinning identity and trust fabric to support connections between authorised people in a safe, secure manner.

8.2 The 21st century learning agenda

The traditional ‘chalk and talk’ mode of teaching is giving way to a variety of learning modes that involve ICT. In some instances no face-to-face interaction is involved at all. Increasingly teaching and learning incorporates and is mediated by various forms of technology. This trend provides a significant policy driver around the implementation of infrastructure that facilitates 21st century learning.
Despite this shift, the principles of effective and efficient learning remain unchanged, irrespective of whether the learning occurs in the classroom, at home, in the workplace, on the sports field, or online. People learn best when they:

- are motivated to learn and have their interest and curiosity aroused
- focus their attention
- are able to make connections to their previous experiences and learning
- are engaging with ideas relevant to their individual level of maturity
- are actively engaged and not asked to learn by rote
- are in low threat but high challenge environments
- are challenged to articulate their understanding, typically in communication and collaboration with others
- are presented with learning challenges related to their experience of the real world.

ICT can support effective learning because it can provide personalised learning opportunities and collaborative learning environments consistent with these principles. Web 2.0 tools are particularly effective enablers of collaborative learning approaches, which are essential for the construction of meaning through language.

The SICTAS investigation, *Collaboration in teaching and learning*\(^{105}\) (CTL) provides several examples of how ICT, particularly social networking software, benefits students by providing learning experiences that correspond to the model of effective learning laid out above:

- they encourage student engagement and increase participation, particularly among quieter students who can work collaboratively online without the anxiety of raising questions in front of a class of peers\(^{106}\)
- they enable expression through less traditional media such as video\(^{107}\)
- they extend learning opportunities by encouraging online discussion between students outside the physical bounds and working hours of the learning institution\(^{108}\)
- students feel a sense of ownership and engagement when they publish their work online, which can encourage attention to detail and improved quality of work overall.\(^{109}\)

Two current, recent statements on the goals of Australian education capture the trend towards 21\(^{st}\) century learning. Firstly, relevant to the school sector, in 2008 all Australian Education Ministers made a declaration to set the direction of Australian schooling for the following ten years. The goals, contained in the *Melbourne Declaration on Educational Goals for Young Australians*\(^{110}\), were developed by the Education Ministers in collaboration with the Catholic and independent school sectors following public consultation. They place a strong emphasis on ICT in teaching and learning during the school years.

The *Melbourne Declaration*’s preamble discusses major ongoing changes in the world that are placing new demands on Australian education, and technology features strongly as a driver:

Globalisation and technological change are placing greater demands on education and skill development in Australia and the nature of jobs available to young Australians is changing faster than ever. Skilled jobs now dominate jobs growth and people with university or vocational education and training qualifications fare much better in the employment market than early school leavers.\(^{111}\)
Rapid and continuing advances in information and communication technologies (ICT) are changing the ways people share, use, develop and process information and technology. In this digital age, young people need to be highly skilled in the use of ICT. While schools already employ these technologies in learning, there is a need to increase their effectiveness significantly over the next decade.\textsuperscript{112}

In addition, the \textit{Melbourne Declaration} sets out a definition of successful learners. They ‘have the essential skills in literacy and numeracy and are creative and productive users of technology, especially ICT, as a foundation for success in all learning areas.’\textsuperscript{113}

The \textit{Melbourne Declaration} lays out elements of a ‘world-class curriculum,’\textsuperscript{114} incorporating the national curriculum and curricula specified at the state, territory and local levels that is also underpinned by consideration of ICT:

> As a foundation for further learning and adult life the curriculum will include practical knowledge and skills development in areas such as ICT and design and technology, which are central to Australia’s skills economy and provide crucial pathways to post-school success.\textsuperscript{115}

Secondly, also in 2008, the Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA) signed off on the \textit{Joint Ministerial Statement on Information and Communications Technologies in Australian Education and Training: 2008-2011},\textsuperscript{116} which was developed by AICTEC. The \textit{Ministerial Statement} expresses fundamentally the same rationale for the integration of ICT in education and training as the \textit{Digital Education Revolution},\textsuperscript{117} discussed below, and the \textit{Melbourne Declaration}; that is, ICT enhances teaching and learning and ICT skills are critical for the Australian economy. Of relevance to this investigation, the \textit{Ministerial Statement} also discusses the infrastructure requirements associated with the implementation of ICT across Australian education and training:

> Technology rich learning environments will be underpinned by a secure and robust infrastructure, where software, computers and ICT equipment, networked systems, technical support and access to high speed broadband and online services will support educators in the delivery of world class education and training. Jurisdictional and cross sectoral access to networks and digital repositories of resources that are affordable, reusable, discoverable and shareable, will be supported by policy, sustainable resourcing and technical systems and standards that enable the building and exchange of knowledge and resources.\textsuperscript{118}

\subsection{8.2.1 National curriculum}

The Australian Curriculum, Assessment and Reporting Authority (ACARA)\textsuperscript{119} is charged with the development of a rigorous, world class national curriculum from Kindergarten to Year 12 by 2010, starting with the learning areas English, mathematics, the sciences and history,\textsuperscript{120} and based on continua of learning in literacy and numeracy.\textsuperscript{121}

The implementation of a national curriculum presents an opportunity for gathering of information and specifications around national software infrastructure to facilitate the teaching and learning required. It also presents an imperative around the standards that will apply around resources to be developed to fit within the national curriculum, a question of national software infrastructure.

The national curriculum can be considered a driver for national software infrastructure as part of both the 21\textsuperscript{st} century learning agenda and other Government policy.
8.3 Drivers in other Government policies

8.3.1 Equity and social inclusion

The Australian Government’s social inclusion agenda is driving many aspects of Government policy. It is a whole-of-government approach, involving collaboration and coordination across a range of Australian Government departments, including DEEWR. The Australian Government sets out eleven principles of social inclusion and equity of access to education features prominently among them.

The Digital Education Revolution (DER) is a key element of the Australian Government’s education reform agenda, and equity of access in rural and remote Australia is one of the DER’s main anticipated outcomes. For example, high speed broadband, provided in fixed-line, wireless and satellite modes, will facilitate video conferencing for distance education and provide better opportunities for students in regional and rural areas. Rich curriculum content, disseminated across a fast broadband network, will help to overcome the disadvantages faced by schools and teachers in rural and remote locations.

Social equity for Australians living in rural and remote areas is also part of the rationale behind the Australian Government’s National Broadband Network (NBN) initiative. The Australian Government has announced it will establish a new company to build and operate a fibre to the premises (FTTP) 100 mbps National Broadband Network (NBN). The new network will dramatically improve broadband for all Australians, including those living in regional and rural Australia. In addition to this equity imperative, the NBN rollout also presents an imperative and offers an opportunity and around national software implementation.

The previous SICTAS CTL investigation includes discussion of infrastructure-related issues in its analysis of issues around educational collaboration and ICT. The first relevant observation is that access for students and educational staff to enabling infrastructure ‘varies between jurisdictions and sectors, and between learning organisations.’ Specifically regarding the VET and higher education sectors, the CTL investigation presents the observation that a conceptual infrastructure for ICT in education exists in VET through the Framework, as discussed in further detail below. The higher education sector has no such sector-wide commitment to the provision of ICT. The CTL investigation touches on the benefits that cross-sectoral software infrastructure can offer which, related to considerations of national software infrastructure, includes equity of access and also smoother transitions between sectors.

8.3.2 Innovation and collaboration

The 2008 report commissioned by the Minister for Innovation, Industry, Science and Research, Venturous Australia: Building Strength in Innovation, discusses the importance of Australian innovation. Venturous Australia opens with the statement that ‘We have known for several generations that innovation pre-eminently determines our prosperity. The report mentions the importance of education to Australian innovation, but also acknowledges in passing that innovation within education is critical:

We must also ensure that our most globally competitive industries, such as mining, agriculture, education and tourism, receive adequate research funding support to keep them at the cutting edge.

Venturous Australia frequently discusses collaboration, domestic and international, within and across sectors, as an important factor that enables innovation. Collaboration within the broader Australian
economy is vital to Australia’s innovation agenda and productivity but, within education, collaboration between educators is similarly vital to achieve innovation. There is no reason for collaboration to be constrained within the geographical boundaries of state and territory education jurisdictions; national software infrastructure that facilitates domestic and international collaboration can make a significant contribution to innovation in Australian education and more broadly to a productive Australian economy.

8.3.3 Australia’s productivity agenda

The *Skilling Australia for the Future* discussion paper identifies issues facing Australia around workforce participation and productivity, including a limited supply of skilled labour, Australia’s skill level relative to international competitors and an aging population. *Skilling Australia* outlines the Australian Government’s agenda, ‘focused on economic and social reforms to drive productivity and workforce participation,’ and notes that it addresses critical areas including infrastructure.

8.4 Technology drivers

8.4.1 Sustainability

Sustainability factors are significant considerations in any infrastructure decision. These considerations are discussed in the SICTAS CTL investigation and paraphrased below.

- If we invest in this technology, is the financial investment sustainable in the long term?
- What are the resource implications for training, maintenance, and enhancement?
- Is the technology scalable? Can it grow and extend to meet new requirements?

These considerations, if appropriately factored into software infrastructure decisions, will ensure services continue to exist and are available when required in the future.

Decisions around software infrastructure or any other area of technology are complicated by technology’s nature; it is a truism that technology changes constantly and rapidly. Decision making around software infrastructure must be cognisant of this, seeking solutions that are independent of specific technologies.

8.4.2 Interoperability

Interoperability is another important factor in infrastructure decisions, also discussed in the SICTAS CTL investigation. Correct decisions around interoperability ensure return on investment is protected.

- Is the technology interoperable with current technology in place; that is, is it backwards compatible?
- Can the technology be integrated with existing systems?
- Will the technology interoperate with other systems?
- Is the technology standards-compliant to enable content and data sharing?
- Is there a need for a middleware layer between the technology and other applications, platforms or systems?
In the Australian context, this issue is complicated by the need for any national infrastructure to interoperate with disparate technologies in the states, territories and independent education jurisdictions across all education sectors.

8.4.3 Emerging technologies

As noted above, it is a truism that technology changes constantly and rapidly, and this makes decision making about the implementation of any technology, including national software infrastructure, constantly challenging. There are no easy answers to the question of what technology to choose, and when and how it should be implemented. New software will continue to be developed so the decision making process is constant and ongoing. Decision makers must be prepared to embrace constant innovation and change and establish processes and procedures that support it.

The final deliverable of the SICTAS project will be a report on emerging technologies that will present a futures thinking overview of emerging technologies and the related implications for policy makers and address issues, including:

- impact on education and training
- associated opportunities and risks
- business cases for adoption
- challenges to implementation in the Australian context.

The annual Horizon Report ‘charts the landscape of emerging technologies for teaching, learning and creative expression’ and is also an excellent resource for consideration of emerging technologies in education.

Emerging technologies of current relevance to education include the following:

- **Cloud computing**
  This is a mode of computing in which resources including infrastructure, platforms and software are provided as a service over the internet. Beyond user level needs, users do not require knowledge of, expertise in, or control over the technology they use ‘in the cloud.’ They do not own the infrastructure, platforms or software that they use, and do not need to install or run the applications they use on their own computer. This alleviates the need for software maintenance and ongoing support, and necessitates only a connection to the internet.

- **Immersive learning environments**
  There are various types of immersive learning environments, which may or may not have been originally developed with educational applications in mind.

  A 3D (three dimensional) virtual world is a software application that gives users the experience of being agents in an online environment, with their selves represented by avatars or online personas. Virtual worlds can support the development of communication, cooperation, and collaborative behaviour. They also provide opportunities for student immersion in learning experiences and for simulation of situations and equipment that would be otherwise prohibitively expensive.

  Games are another form of immersive environment. Learners can achieve a range of learning when playing electronic games, and there are ‘serious games,’ specifically designed for education.

- **Web 2.0**
  Web 2.0 is a term that describes three aspects of the internet that have increased in
prominence over the last few years: participation, collaboration and networking. Participation means that users can contribute to the content of Web 2.0 sites as well as consuming it, and leads to the possibility that users can collaborate online, working together to create content, and also network for social or other reasons.

- **E-portfolios**
  The term e-portfolio is used to describe a wide number of software application areas that provide a range of different types of services. These services include, but are not limited to:
  - assessment
  - evidence of achievement
  - presentation
  - reflection
  - planning and goal setting.

  E-portfolios are used in many situations including by:
  - educators
  - learners
  - career seekers
  - groups
  - regions
  - countries.

  There is a pending SICTAS report on e-portfolios that will provide comprehensive information on national implementation of e-portfolios.

- **Mobile technologies**
  M-learning, or mobile learning, is a broad term describing learning that involves mobile technology. Many different mobile technologies can be used in m-learning, including:
  - personal digital assistants (PDAs, or handheld computers)
  - mobile phones
  - personal media players (such as the Apple iPod)
  - handheld game consoles (such as the Nintendo Game Boy or Sony PlayStation Portable).

  The main feature of m-learning is that it is mobile. Depending on the form of the technology and the nature of the lesson, learning can take place wherever and whenever the learner chooses.

  It is important that emerging technology does not drive decisions around the implementation of national software infrastructure at the expense of the human, economic and social drivers outlined above. Technologies will continue to emerge; addressing these broader concerns can help to ensure that the investment in ICT realises desired social and economic outcomes.

### 8.5 A national strategy for interoperability standards

As noted above, in 2007 AICTEC commissioned a study into interoperability standards across all education sectors. The Croger Research Report: Interoperability Standards Across the Australian
Education and Training Sector identified the strategic need for and recommended the development of a national cross-sectoral collaborative framework to progress the development of interoperability frameworks and shared infrastructure across all sectors of education and training.

The Research Report presents an excellent summary of interoperability and standards requirements, which is paraphrased below. Firstly, the Research Report identifies drivers for interoperability in Australia’s education and training sectors:

1. Globalisation of education and training and the benefits afforded through collaboration with international partners
2. Changing community expectations
3. Increased mobility of students
4. New modes of teaching and learning including modes supported by technology
5. Requirements for greater efficiency
6. Accountability requirements
7. Requirements to recognise skills and prior learning
8. Trends towards ubiquitous learning and increasing off-campus delivery
9. Blurring of boundaries between sectors (e.g., schools offering VET courses)
10. Collaborative approaches to curriculum alignment
11. Collaborative approaches for some assessment activities
12. Sharing of educational resources between institutions and sectors
13. Sharing of research data and infrastructure between research institutions and projects
14. Use of some government sector infrastructure by non-government education organisations
15. Intellectual property issues
16. Changing legal requirements
17. Requirements for security of resources
18. Government agendas for electronic service delivery
19. International treaty obligations including those relating to the World Trade Organisation and various free trade agreements
20. Trends in information management

The Research Report makes the case for interoperability for education institutions, but notes that interoperability is frequently discussed as a technical concept. This is the case in this investigation, but there are several important modes of interoperability operating at different layers across the organisations involved. The benefits of interoperability across these layers are improvements in the following areas:

- service outcomes
- service quality
- accessibility to services
- efficiency, cost saving and affordability
- flexibility to meet future changes
• decision making through better management information
• accountability
• security
• safety.\textsuperscript{150}

8.6 SICTAS ICT in Learning Symposium

The national ICT in Learning Symposium: Planning for Change was hosted by Education.au in Sydney on 1 May 2009 as part of the SICTAS project. Sixty participants attended, including representatives from all education and training sectors, and from the technology industries. All states and territories were represented. There was significant discussion at the symposium around national infrastructure for education, and the summary below is of the communiqué disseminated after the symposium.\textsuperscript{151} It captures the current situation around national software infrastructure for education and key directions for policy ongoing.

There has been significant work across the education and training sector in the development of frameworks and systems that provide national approaches to the provision of services and resources, for example AARNet, the Australian Access Federation, the Australian Flexible Learning Framework, and The Learning Federation.

Collaborative learning and connectedness are key characteristics of 21st century learning. It is important that infrastructure development – including physical infrastructure, software, standards and guidelines, and learning resources – leverages from the considerable achievements to date and is designed to continue to foster collaboration.

Governments have a crucial role in supporting the development of infrastructure at national and jurisdictional levels. A significant issue regarding infrastructure is the tension between centralised platforms and users’ desire for control of their technology environments. National infrastructure should support integration of personal learning environments with systemic structures within formal education environments – thus enabling educators and learners to use the tools they like while connecting to services securely and transparently.

This does not always imply a centralised platform, but does mean that the ‘glue’ that keeps the whole system running requires a strategic focus, national partnerships, and collaborative planning, monitoring and maintenance. This includes implementation of interoperability standards, frameworks for decision making for the adoption of new ICTs, and strategies for sharing educational content, services and good practice.

While it is recognised that governments want to minimise risk and ensure equity of experience and access for learners to ICT for teaching and learning, progress is often impeded by complex decision making and implementation processes. A challenge for policy makers and the education sector is to provide an opportunity for educators to trial, evaluate, select and implement new ICTs in ways that are appropriate to their local needs without the burden of heavy, centralised controls.

Key directions for policy include:

• development of a management, maintenance and governance model for managing a complex distributed and connected environment for all stakeholders
• development of decision making frameworks that describe minimum standards for interoperability to encourage national integration of tools and services while allowing for local flexibility
• provision of sandpit spaces for trial and evaluation of new technologies
• promotion of frameworks and systems to encourage sharing of content and best practice in teaching and learning.
9 Appendix B: National and international initiatives

Various initiatives are already in place in the Australian national software infrastructure space. This is also true of the UK, where significant activity has already taken place. This appendix reviews current initiatives in Australia and in the UK with the aim of setting the context for the analysis that follows.

Some of the projects surveyed below are continuing, but several of the projects are complete, with no ongoing work in the space, or with R&D project outcomes not integrated into national software infrastructure. This illustrates the following funding needs, as detailed among others in the recommendations that flow from this investigation:

- funding to support the leadership and governance processes necessary for the development and ongoing enhancement of national software infrastructure for education
- a national body to operate those elements of the national software infrastructure that are best implemented as central shared services on behalf of all stakeholders.

9.1 Croger research report

In 2007 AICTEC commissioned a study into interoperability standards across all education sectors. The Croger Research Report: Interoperability Standards Across the Australian Education and Training Sector presents a summary of current work on interoperability. The elements paraphrased below are collaborative initiatives, not covered elsewhere in this investigation.

Link Affiliates
Link affiliates is a small team of strategic, technical and project management experts working on a wide range of standards-related initiatives, funded by DEEWR and DIISR.

AICTEC National Interoperability and Digital Architecture Advisory Group
Formed in October 2008, the National Interoperability and Digital Architecture Advisory Group, and its Reference Group, provide AICTEC with expert cross-jurisdictional and cross-sectoral advice on a technical framework to support online learning and the implementation of the Digital Education Revolution.

In addition, Australian experts also participate in international and national bodies that develop standards and specifications, and AICTEC supports effective informal networks of collaboration between experts and practitioners in the different Australian education and training sectors.

9.2 edna

edna (Education Network Australia) is an online network for all sectors of Australian education and training. Online since 1997, and managed and maintained by Education.au, edna now provides:

- educational resources from Australian and international collections
- an online community of educators, me.edu.au
- feeds and email discussion lists for educators
• group collaboration spaces, including wiki, blog, and podcasting utilities.\(^{160}\)
edna’s team also runs workshops\(^{161}\) for Australia’s educators in all states and territories.

edna has grown and developed since it was first launched. At the time it exemplified current thinking around educational technology infrastructure; it was an online, quality assured resource repository. The services offered by edna have grown significantly since that time, to the extent that edna offers me.edu.au, a service that encapsulates the principles of web 2.0 for educators. The edna project is still in progress and the services it offers will continue to develop, subject to feedback received in ongoing consultation\(^{162}\) with stakeholders.

9.3 AARNet

Australia’s Academic and Research Network (AARNet) provides high capacity leading edge internet service for the tertiary education and research communities and their research partners.\(^{163}\) The services are designed to enable AARNet’s customers to:

• collaborate and interact in more effective and efficient ways
• gain access to and provide information to assist in the delivery of ICT solutions to benefit teaching, learning, research and administration
• participate in alternative and more flexible modes of course delivery.\(^{164}\)

9.4 The Le@rning Federation / Scootle

The Le@rning Federation (TLF),\(^{165}\) a collaborative initiative of all Australian and New Zealand governments, develops digital curriculum content for Australian and New Zealand schools.\(^{166}\) The content is:

• free for all Australian and New Zealand schools
• developed specifically to support students' learning of key concepts and skills detailed in all Australian and New Zealand curriculum documents
• made available to schools through educational jurisdictions.\(^{167}\)

TLF has also been active in creating infrastructure for content and setting standards and specifications.\(^{168}\) A significant example of infrastructure for content is Scootle,\(^ {169}\) which provides access to thousands of items of TLF digital content. This is an example of early thinking around infrastructure; that is, it is repository infrastructure in the form of a website in the manner of edna. Also in the manner of edna, Scootle has grown beyond a simple repository. It now includes sophisticated resources to assist teachers create student learning paths. Scootle was developed by Education.au.

9.5 LORN

LORN,\(^{170}\) formerly the Learning Object Repository Network, currently allows teachers and trainers to find and use online training resources from across the Australian Vocational Education and Training (VET) sector.\(^{171}\) This year (2009) development of the LORN service will facilitate e-transaction and licensing facilities, allowing users to locate free and for-cost learning objects, license them as appropriate for the learning objects and their needs, then download them for use in teaching and learning.

LORN is an initiative of the Australian Flexible Learning Framework (Framework).\(^{172}\)
9.6 Australian Research Repositories Online to the World

The Australian Research Repositories Online to the World (ARROW)\textsuperscript{173} project was initially sponsored as part of the Australian Government’s Backing Australia’s Ability program. The objectives of the ARROW project were to:

- identify and test software to support best-practice institutional digital repositories at the ARROW Consortium member sites to manage e-prints, digital theses and electronic publishing.

- develop and test a national resource discovery service using metadata harvested from the institutional repositories by the National Library of Australia (NLA).\textsuperscript{174}

The ARROW service is now operated by the NLA.

9.7 Schools Interoperability Framework Association

The Schools Interoperability Framework Association (SIFA) is acting to create a set of rules and definitions which enable software programs from different companies to share information.\textsuperscript{175} This initiative is in response to the challenge facing the education sector of a lack of interoperability, which means:

- applications and their data are isolated from one another

- redundant data entry is common

- disconnected applications increase support costs

- data reporting is costly and inefficient

- data is inaccessible to decision makers and can be inaccurate.\textsuperscript{176}

In response, the Schools Interoperability Framework (SIF)\textsuperscript{177} is a specification to:

- define standard formats for shared data e.g., student demographics information

- define standard naming conventions for this shared data

- define the rules of interaction among software applications.\textsuperscript{178}

9.8 Australian Government Technical Interoperability Framework

The Australian Government Technical Interoperability Framework (Interoperability Framework)\textsuperscript{179} was a first step in establishing technical interoperability for the exchange of data and harmonisation of business transactions within a trusted environment. The Interoperability Framework:

... sets out a common language, conceptual model and standards that Australian Government agencies can employ as a basis for interoperating to deliver the Australian Government's policy and program priorities.\textsuperscript{180}

While this is not an example of national software infrastructure, it demonstrates awareness within Government of interoperability issues and the benefits that can be gained from technical, information, and business process interoperability across whole of Government. As noted above, the Australian Government’s technical interoperability agenda is managed by the Australian Government Information Management Office (AGIMO).\textsuperscript{181}
9.9 United Kingdom

In the UK Becta (formerly the British Educational Communications and Technology Agency) is a significant component of the push for effective and innovative use of technology in learning. Becta conducts a great deal of research in the field, and Becta’s work informs much of this investigation’s look at the national software infrastructure situation in the UK.

It is important to note that the environment around UK education is significantly from the Australian situation. Each of the countries of the United Kingdom has a separate education system under a separate government. The UK Government is responsible for education in England, led by the Secretary of State for Children, Schools and Families and the Secretary of State for Innovation, Universities and Skills. The day to day administration and funding of state schools is the responsibility of Local Education Authorities (LEAs). The Scottish Government is responsible for education in Scotland, led by the Cabinet Secretary for Education and Lifelong Learning. The Welsh Assembly Government is responsible for education in Wales and the Department of Education for education in Northern Ireland led by the Minister for Education, with local level administration from five Education and Library Boards. Most pupils are educated in state schools, but there is also an important private education sector.

On its website, Becta states that it is:

... working with DfES [the Department for Education and Skills, replaced by the Departments for Children, Schools and Families (DCSF) and Innovation, Universities and Skills (DIUS)] and key partners to design a national ICT infrastructure for education that will provide significant system-wide benefits of coherence and interoperability (working to common standards), together with allowing local choice of a range of ICT services that deliver increased reliability at a sustainable and affordable price.

Becta’s model for national digital infrastructure has four elements, with a project around each. The first, data services, includes data warehousing, management information systems and a range of data mining tools. The second, learning services, includes the management, provision and availability of learning content. The third, infrastructure services, includes support of the system and the seamless integration of services. Finally, connectivity services link all elements of the model together, connecting institutions to the wider educational community and to the internet. Overall, the model aims to:

- improve data flows within and between schools, regionally and nationally
- unify interoperable systems which provide a stable platform for learning and teaching
- reduce the technical burden on schools, allowing them to focus on the use of technology in teaching and learning rather than its management
- introduce a coherent and reliable technology at an affordable and sustainable price.

Many of the considerations Becta raises in discussion of these elements are local school issues, but national implications are also noted. An excellent example of this is presented in a 2005 Becta report, School Management Information Systems and Value for Money. In the report, following consultation with LEAs, suppliers, principal associations and within DIES, Becta made nine recommendations around the procurement of school Management Information Systems (MIS). The third recommendation is of great relevance for considerations of national software infrastructure in the Australian context:

Recommendation 3
That Becta will establish a supplier-independent and open interoperability architecture to create the opportunity for improved interoperability at the school level and at the LEA or regional broadband consortium level. Additionally, Becta’s interoperability arrangements will draw, to the maximum extent possible, on ongoing work across Government on interoperability standards.\textsuperscript{196}

There is clear potential in Australia for a national approach to interoperability and standards, especially when that approach draws on work across whole-of-Government.

**The National Education Network**

The National Education Network (NEN) is a dedicated, educationally focussed secure broadband network for teaching and learning in the UK.\textsuperscript{197} Between 2000 and 2001 ten Regional Broadband Consortia (RBCs) were set up with the aim of realising the promise of broadband technology in education and connecting all learning communities across England.\textsuperscript{198} During 2003 the regional networks were connected by high speed links via the JANET network\textsuperscript{199} (originally developed for the Higher Education sector), creating a single and secure private network, the NEN.\textsuperscript{200} The NEN provides schools with a range of broadband services with no need for pupils to go onto the internet.\textsuperscript{201} Many internet services are mirrored within the NEN,\textsuperscript{202} with the control and security this implies. Users can also access the wider internet through the NEN’s secure gateways, with access policies managed by local RBCs.\textsuperscript{203}

From a software infrastructure point of view, the NEN provides a delivery mechanism for new regionally and nationally managed services, including a unified authentication and authorisation infrastructure and an agreed standards and interoperability framework.\textsuperscript{204}

**Federated access management**

The UK Access Management Federation for Education and Research was launched in November 2006.\textsuperscript{205} It provides UK schools, along with the higher education and research sectors with a framework for accessing online learning material by using Shibboleth identity management software.\textsuperscript{206} This allows institutional single sign-on to resources through federated, devolved authentication.\textsuperscript{207}

Federated access management has advantages for learners and teachers and for institutions. Learners and teachers:

- need only an institutional username and password
- can be confident that personal information is not being unnecessarily disclosed to third parties
- can access resources while they are outside the school environment
- can more easily access appropriate content.\textsuperscript{208}

Institutions:

- do not need to manage resource licences
- do not need to assign usernames and passwords
- can more easily comply with regulatory requirements
- can potentially use the same access control for internal and external resources.\textsuperscript{209}

**e-Framework for Education and Research**

The e-Framework for Education and Research (e-Framework) is an initiative that provides information to institutions on investing in and using technology infrastructure.\textsuperscript{210} DEEWR is a founding partner in the initiative with JISC. The New Zealand Ministry of Education\textsuperscript{211} and The Netherlands’ SURF Foundation\textsuperscript{212} have subsequently joined. The e-Framework’s primary goal is to ‘facilitate technical
interoperability within and across higher education and research through improved strategic planning and implementation processes, and it operates on the following guiding principles:

- a service-oriented approach to system and process integration
- development, promotion and adoption of open standards
- community involvement in development
- open collaborative development activities
- flexible and incremental deployment.

In brief, the e-Framework is:

… a framework for thinking about and documenting IT systems in terms of component behaviours described as services and aimed at understanding better the points at which we need to integrate and interoperate.

**Unique learner number**

Since September 2006 the UK has implemented a Unique Learner Number (ULN) system, which means that the Learner Record of every citizen over the age of 14 is identified by a unique, randomly generated ten digit number. The ULN is being made available across the UK education sectors: schools, sixth form colleges, further education and higher education, and ‘will allow students to build a lifelong record of their learning participation and achievements, which they can access and choose to share.’

The Learner Record is ‘an aggregation of records about an individual’s learning that has already been collected by UK education bodies.’ With the aim of improving the flow of information about learners from schools to other education providers and ultimately to employers, the ULN is supported by a set of common data definitions, adopted by all organisations which collect information about learners.

Each ULN is issued and held by the internet-based Learner Registration Service (LRS). Learners will need to:

… use their number each time they want to see or confirm the details held about them on their Learner Record. The ULN also means information within the Learner Records is secure and cannot be shared with other organisations (including statutory bodies) without the prior consent of the learner.

**9.10 Australian Access Federation**

The Australian Access Federation (AAF) will develop and deploy an infrastructure to facilitate trusted electronic communications and collaboration within and between Australian and international higher education and research institutions. The aim of the AAF is to provide a means of allowing a member institution to trust the information it receives from another member so that access to resources and secure communication can be conducted seamlessly, in a way that will support effective collaboration between users.

The AAF Project is sponsored by the Australian Government's Department of Innovation, Industry, Science and Research (DIISR). The funding was provided through the Systemic Infrastructure Initiative (SII) as part of the Government's Backing Australia's Ability - Building Our Future Through Science and Innovation program.
The AAF will enable researchers, staff members and students at member universities or research institutions to log in using a single account issued by their own institution and access a wide range of resources internal and external to the institution, including:

- data collections and data grids
- scientific instruments, modelling and visualisation tools, and computing resources
- collaboration environments and workspaces for virtual teams
- scholarly resources and publications
- e-learning resources and learning object collections
- national higher education and research administrative systems.\(^{229}\)

This means:

- users can collaborate more easily with colleagues because it is easier to share access to tools and resources
- users need to remember only one account from their own institution instead of requesting and remembering accounts from several different resource providers.\(^{230}\)

The AAF will allow resource providers to provide access to their resources or services to authorised users in a secure way without having to issue or manage user accounts. Institutions and resource providers in the federation agree to abide by the federation policies and trust the information that each passes to the other.\(^{231}\)

Institutions will benefit from the AAF by enabling their research, academic, and administrative users to access a wide range of resources and to collaborate more easily with colleagues in Australia and in other countries with which the AAF has a peering relationship.\(^{232}\)

The Meta Access Management System (MAMS),\(^{233}\) funded by the Australian Government through the Backing Australia’s Ability\(^{234}\) initiative, was the proof of concept that led to the AAF. The AAF initiative is currently making progress under the management of the Council of Australian University Directors of Information Technology (CAUDIT).\(^{235}\)

### 9.11 Learner Identity Management Framework

In 2005 the Australian Education Systems Officials Committee (AESOC) endorsed the Australian ICT in Education Committee’s (AICTEC) proposal to examine the desirability, nature and options for the development of a national, cross-sectoral Learner Identity Management Framework (LIMF) for the education and training sectors. Specifically, the project was about developing protocols for a reliable and accountable system for jurisdictions and sectors to access and exchange the records, progress and characteristics of individual learners.\(^{236}\)

This project resulted in the development of a Charter of Principles for Learner Identity Management\(^{237}\) which was endorsed by the Ministerial Council for Vocational and Technical Education (MCVTE) in December 2006.\(^{238}\)

The Charter provides guidance for education and training providers in relation to the access, management and transfer of learner information.

- **Integrity and security**
  Collectors and custodians of learner data will develop and make publicly available policies
that demonstrate their commitment to maintaining the integrity and security of learner information.

- **Identity resolution**
  Custodians of learner data will put in place policies and procedures for verifying the identity of individual learners and for ensuring any data they transfer to or receive from other custodians relates to the learner in question and to no other person.

- **Data management**
  Custodians of learner data will develop their data collections with a view to achieving terminology, definitions and meanings that are consistent with those used by other custodians.

- **Data exchange**
  Custodians of learner data will work towards achieving a common technical framework and language for transferring information across learner data repositories.

- **Policies and procedures**
  Custodians of learner data will establish and maintain robust policies and procedures for protecting the privacy of individual learners and for recording relevant consents.

The final report of the LIMF project\(^{239}\) was submitted to AICTEC in March 2006. It identifies the key objectives of a LIMF as:

- addressing issues associated with learner mobility and smoothing learner transitions
- assisting in the detection of learners at risk of disengagement
- supporting enhanced longitudinal research
- supporting evaluation of targeted programs, and
- supporting ePortfolios/Learner-controlled personal data.\(^{240}\)

The report proposes a framework comprising five elements to guide the sharing and exchange of learner data across jurisdictions and sectors:

- **A trust scheme**
  This involves establishing ground-rules such that the owners of information can be confident that any data they transfer will be handled appropriately by the recipient.

- **Identity resolution**
  The development of agreed approaches for establishing and verifying the identity of each learner.

- **Data management**
  Consistent definitions of learner information types and meanings across sectors and jurisdictions.

- **Data exchange protocols**
  A common technical framework and language for transferring information across data repositories.

- **Policy enforcement**
  Systems for protecting the privacy of learners and for recording their consents.\(^{241}\)

To bring the framework into being, the report advocates a Learner Identity Management Architecture (LIMA) that identifies and expands each element of the framework.\(^{242}\)
The report also suggests that, as the LIMF is operationalised, learner information is either transferred directly between providers (who would acquire or develop a technical capacity to support connections with every other provider) or is transmitted via a central ‘brokering’ service, which would function as a national data clearing-house.

9.12 Persistent identifier linking infrastructure

The Persistent Identifier Linking Infrastructure (PILIN) project arose in response to the realisation that sustainable identifier infrastructure is required to deal with the vast amount of digital assets being produced and stored within universities. This is a particular challenge for e-research communities where massive amounts of data can be generated with no means of managing this data over any length of time. The emphasis in the PILIN Project was on building identifier management infrastructure based on a technology (Handle) developed to underpin sustainable global identifier infrastructure.

The overarching objective of the PILIN project was to strengthen Australia’s ability to use global identifier infrastructure. Its outputs were:

- best practice and policy guides for the use of persistent identifiers in Australian e-learning, e-research, and e-science communities
- use cases describing community requirements for identifiers and business process analysis relating to these use cases
- e-framework representations of persistent identifier management services that support the business requirements for identifiers
- a ‘pilot’ shared persistent identifier management infrastructure usable by the project stakeholders over the lifetime of the project, including services for creating, accessing and managing persistent digital identifiers over their lifetime
- software tools to help applications use the shared persistent identifier infrastructure more easily
- report on options and proposals for sustaining, supporting (including outreach) and governing shared persistent identifier management infrastructure.

9.13 VET learner ID

Education.au recently completed a study for the Framework, Managing learner information: Important considerations for implementing e-portfolios in VET. The study identifies privacy and security requirements for learner content in e-portfolios and informs consideration of national software infrastructure.

The Managing learner information: Important considerations for implementing e-portfolios in VET study considers the auEduPerson specification, which provides a set of recommended attributes to describe users of the AAF, discussed above.

auEduPerson core attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>auEduPersonSharedToken</td>
<td>A unique identifier</td>
</tr>
<tr>
<td>Field</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>displayName</td>
<td>Preferred name of a person to be used when displaying entries.</td>
</tr>
<tr>
<td>eduPersonAffiliation</td>
<td>Specifies the person's relationship(s) to the institution (e.g. student, staff, etc)</td>
</tr>
<tr>
<td>eduPersonEntitlement</td>
<td>Uniform Resource Indicator (URI) (either Uniform Resource Name (URN) or Universal Resource Locator (URL)) that indicates a set of rights to specific resources.</td>
</tr>
<tr>
<td>eduPersonScopedAffiliation</td>
<td>Specifies the person's affiliation within a particular security domain</td>
</tr>
<tr>
<td>eduPersonTargetedID</td>
<td>A persistent, non-reassigned, privacy-preserving identifier for a user shared between an identity provider and service provider</td>
</tr>
<tr>
<td>mail</td>
<td>Email address</td>
</tr>
</tbody>
</table>

The auEduPerson specification would require modifications if it were adopted in sectors other than higher education, for which it was developed. Nonetheless, it illustrates the potential of and considerations around a common language to identify Australian education students and staff. Significantly, a specification like this can facilitate information sharing between education institutions via a single sign on approach.250
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URLs listed below may change.


http://www.aarnet.edu.au/


About ARROW. ARROW.
http://www.ar Arrow.edu.au/about/

About LORN. Australian Flexible Learning Framework.
http://lorn.flexiblelearning.net.au/About.aspx

About the Board | ACARA. 2009. Commonwealth of Australia.
http://www.acara.edu.au/about_us/about_the_board.html


About us. 2009. The Le@rning Federation.

http://www.deni.gov.uk/index/7-special_educational_needs_pg/7-special_needs-a_guide_for_parents_pg/7-special_educational_needs-a_guide_for_parents-contents_pg/7-special_educational_needs-a_guide_for_parents-addresses_of_elbs_pg.htm


A Trust Federation for Australian Schools and VET. 2008. Education.au.

http://www.flexiblelearning.net.au


Australian Research Repositories Online to the World. ARROW.
http://arrow.edu.au/


http://www.flexiblelearning.net.au/fix/webdav/site/fixsite/shared/E-Portfolios/Managing_Learner-Information_FINAL.pdf

Boston, Ian. 2008. SAKAI and OpenSocial: a different approach to distributed learning applications.
http://mfeldstein.com/sakai-and-opensocial-a-different-approach-to-distributed-learning-applications

Campus Collaborative Tools Strategy Development. 2009., University of California, Berkeley.
http://collab.berkeley.edu/projects/cctsd/


CAUDIT - Council of Australian University Directors of Information Technology. 2009. CAUDIT.
http://www.caudit.edu.au/

http://en.wikipedia.org/wiki/Cloud_computing

Colley, Andrew. Extra storage as students go Gmail. 2008. Australian IT.


http://www.dcsf.gov.uk/

http://www.dcsf.gov.uk/localauthorities/index.cfm

http://www.dius.gov.uk/
http://www.flexiblelearning.net.au

http://e-standards.flexiblelearning.net.au/

http://www.groups.edna.edu.au/


http://www.edna.edu.au/edna/go/about/pid/2769

http://www.edna.edu


Federated access management. 2007. Becta.  
http://schools.becta.org.uk/index.php?section=lv&&catcode=ss_lv_saf_se_03&rid=11277

http://www.sifinfo.org/us/general-overview.asp

http://wave.google.com/


http://publications.becta.org.uk/download.cfm?resID=38751

Higher Education in a Web 2.0 world: Report of an independent Committee of Inquiry into the impact on higher education of students’ widespread use of Web 2.0 technologies. 2009. JISC.  
http://www.jisc.ac.uk/media/documents/publications/heweb20rptv1.pdf

http://www.nen.gov.uk/

http://www.deni.gov.uk/


Learner Identity Management Framework Project. 2009. AICTEC.
http://www.aictec.edu.au/aictec/go/home/about/cache/offonce/pid/171

Learner Record. 2009. MIAP: Managing Information Across Partners.
http://www.miap.gov.uk/products/learnerrecord/

http://www.miap.gov.uk/products/hrs/
http://www.linkaffiliates.net.au/

http://mams.melcoe.mq.edu.au


https://me.edu.au/login.htm

http://www.identityblog.com/stories/2005/07/05/IdentityMetasystem.htm


Ministerial Council on Education, Employment, Training and Youth Affairs. 2009. MCEETYA. 
http://www.curriculum.edu.au/mceetya/

http://www.minedu.govt.nz/

http://www.myfuture.edu.au/

http://www.dbode.gov.au/communications_for_business/funding_programs__and__support/national_broadband_network


http://www.ncb.org.au/about_the_board/about_the_board.html


National Interoperability and Digital Architecture. 2009. AICTEC. 
http://www.aictec.edu.au/aictec/go/home/about/cache/offonce/pid/270


NSW Government chooses Gmail. 2008. apc. ninemsn.  
http://apcmag.com/nsw_government_chooses_gmail_over_ms_exchange.htm

OAuth. 2009. OAuth.  
http://oauth.net/

OpenID. 2009. OpenID Foundation.  
http://openid.net/

http://code.google.com/apis/opensocial/

PILIN Project. PILIN.  
https://www.pilin.net.au/Welcome/about.htm

PILIN Project: Project Closure Report. 2007. PILIN.  

http://portablecontacts.net/

http://www.21stcenturyschools.com/What_is_21st_Century_Education.htm


Project Objectives. Australian Access Federation.  
http://www.aaf.edu.au/objectives

http://www.flexiblelearning.net.au/flx/go/home/projects/pid/268


http://publications.becta.org.uk/download.cfm?redID=25917

http://www.scootle.edu.au


The Le@rning Federation. 2009. The Le@rning Federation. [http://www.thelearningfederation.edu.au](http://www.thelearningfederation.edu.au)


http://www.aaf.edu.au/  


http://www.innovation.gov.au  

Welcome to the SURF portal. 2009. SURF.  
http://www.surf.nl/en/Pages/home.aspx  


http://wales.gov.uk/topics/educationandskills/?lang=en  

What’s in it for me. 2008. Australian Access Federation.  
http://www.aaf.edu.au/forme  

http://www.nen.gov.uk/  

http://xrds-simple.net/
11 Endnotes

Education.au is not responsible for the content of external sites. Please be aware that some of the URLs listed in the endnotes below may change.


7 About ARROW. ARROW. http://www.arrow.edu.au/about/

8 PILIN Project. PILIN. https://www.pilin.net.au/Welcome/about.htm


13 About ARROW. ARROW. http://www.arrow.edu.au/about/


SICTAS: Software infrastructure Education.au


23 A Trust Federation for Australian Schools and VET. 2008. Education.au.


26 A Trust Federation for Australian Schools and VET. Education.au Ltd, 2008.


National Interoperability and Digital Architecture. 2009. AICTEC. 
http://www.aictec.edu.au/aictec/go/home/about/cache/offonce/pid/270

National Interoperability and Digital Architecture. 2009. AICTEC. 
http://www.aictec.edu.au/aictec/go/home/about/cache/offonce/pid/270

AICTEC Learner Identity Management Framework project: Framework Report (v3.0) 2006. AICTEC. 

Australian Information and Communications Technology in Education Committee. 

National Interoperability and Digital Architecture. 2009. AICTEC. 
http://www.aictec.edu.au/aictec/go/home/about/cache/offonce/pid/270

National Interoperability and Digital Architecture. 2009. AICTEC. 
http://www.aictec.edu.au/aictec/go/home/about/cache/offonce/pid/270

AICTEC Learner Identity Management Framework project: Framework Report (v3.0) 2006. AICTEC. 

Australian Information and Communications Technology in Education Committee. 

What’s in it for me. 2008. Australian Access Federation. 
http://www.aaf.edu.au/forme

NSW Government chooses Gmail. 2008. apc. ninemsn. 
http://apcmag.com/nsw_government_choses_gmail_over_ms_exchange.htm


National Interoperability and Digital Architecture. 2009. AICTEC. 
http://www.aictec.edu.au/aictec/go/home/about/cache/offonce/pid/270

AICTEC Learner Identity Management Framework project: Framework Report (v3.0) 2006. AICTEC. 

Australian Information and Communications Technology in Education Committee. 

http://www.edna.edu.au

http://www.aaf.edu.au/

Learner Identity Management Framework Project. 2009. AICTEC. 
http://www.aictec.edu.au/aictec/go/home/about/cache/offonce/pid/171


About ARROW. ARROW. 
http://www.arrow.edu.au/about/
PILIN Project. PILIN. https://www.pilin.net.au/Welcome/about.htm


About ARROW. ARROW. http://www.arrow.edu.au/about/


About ARROW. ARROW. http://www.arrow.edu.au/about/

PILIN Project. PILIN. https://www.pilin.net.au/Welcome/about.htm


http://www.groups.edna.edu.au/  


http://www.edna.edu.au/edna/go/about/pid/2769  

http://www.aarnet.edu.au/  


The Le@rning Federation. 2009. The Le@rning Federation.  
http://www.thelearningfederation.edu.au  

About us. 2009. The Le@rning Federation.  

http://www.scootle.edu.au  


http://www.flexiblelearning.net.au  

Australian Research Repositories Online to the World. ARROW.  
http://arrow.edu.au/  

About ARROW. ARROW.  
http://www.arrow.edu.au/about/  

http://www.sifinfo.org/us/general-overview.asp  


http://www.sifinfo.org/us/general-overview.asp  


188 Addresses of Education and Library Boards. 2009. Department of Education. http://www.deni.gov.uk/index/7-special_educational_needs_pg/7-special_needs-a_guide_for_parents_pg/7-special_educational_needs_-_a_guide_for_parents-contents_pg/7-special_educational_needs_a_guide_for_parents-addresses_of_elbs_pg.htm


Federated access management. 2007. Becta. 
http://schools.becta.org.uk/index.php?section=lv&&catcode=ss_lv_saf_se_03&rid=11277

http://www.ukfederation.org.uk/

Federated access management. 2007. Becta. 
http://schools.becta.org.uk/index.php?section=lv&&catcode=ss_lv_saf_se_03&rid=11277

Federated access management. 2007. Becta. 
http://schools.becta.org.uk/index.php?section=lv&&catcode=ss_lv_saf_se_03&rid=11277

Federated access management. 2007. Becta. 
http://schools.becta.org.uk/index.php?section=lv&&catcode=ss_lv_saf_se_03&rid=11277


http://www.minedu.govt.nz/

Welcome to the SURF portal. 2009. SURF. 
http://www.surf.nl/en/Pages/home.aspx


Unique Learner Numbers. 2009. MIAP: Managing Information Across Partners. 
http://www.miap.gov.uk/products/uln/

http://www.miap.gov.uk/products/lrs/

http://www.miap.gov.uk/products/lrs/

Learner Record. 2009. MIAP: Managing Information Across Partners. 
http://www.miap.gov.uk/products/learnerrecord/

Learner Record. 2009. MIAP: Managing Information Across Partners. 
http://www.miap.gov.uk/products/learnerrecord/

Unique Learner Numbers. 2009. MIAP: Managing Information Across Partners. 
http://www.miap.gov.uk/products/uln/

http://www.aaf.edu.au/

What’s in it for me. 2008. Australian Access Federation. 
http://www.aaf.edu.au/forme

http://www.aaf.edu.au/

http://www.innovation.gov.au


http://www.aaf.edu.au/forme

http://www.aaf.edu.au/forme

http://www.aaf.edu.au/forme

http://www.aaf.edu.au/forme

https://mams.melcoe.mq.edu.au/zope/mams


CAUDIT - Council of Australian University Directors of Information Technology. 2009. CAUDIT.
http://www.caudit.edu.au/

Learner Identity Management Framework Project. 2009. AICTEC.
http://www.aictec.edu.au/aictec/go/home/about/cache/offonce/pid/171

Learner Identity Management Framework Charter Of Principles. 2006. AICTEC.

Learner Identity Management Framework Project. 2009. AICTEC.
http://www.aictec.edu.au/aictec/go/home/about/cache/offonce/pid/171


PILIN Project. PILIN.
https://www.pilin.net.au/Welcome/about.htm

http://www.handle.net/

PILIN Project: Project Closure Report. 2007. PILIN.

https://www.pilin.net.au/Welcome/about.htm

http://www.flexiblelearning.net.au/fx/webdav/site/fixsite/shared/E-Portfolios/Managing_Learner-Information_FINAL.pdf

http://www.flexiblelearning.net.au/fx/webdav/site/fixsite/shared/E-Portfolios/Managing_Learner-Information_FINAL.pdf

http://www.flexiblelearning.net.au/fx/webdav/site/fixsite/shared/E-Portfolios/Managing_Learner-Information_FINAL.pdf