
From E-Assessment to Personalised Learning
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Executive Summary

This paper is written to help Ministries of Education, Local Education Authorities and prospective suppliers understand how to build on E-Assessment and E-Examination to create personalised learning experiences. Taking the three key building blocks of Assessment, Analytics and Intervention, the paper defines a Personalised Learning Platform and its interfaces within a broader schooling ecosystem – the Schooling Enterprise Architecture.

The central proposition to this vision is that using data generated by the growing use of E-Examination and E-Assessment process offers significant value for increasing the effectiveness of the schooling systems.

Schooling system needs to constantly innovate and evolve. This paper sets out a vision for how schooling leaders can make learning even more effective by personalising the learning experience for all school students – without introducing unmanageable complexities.

The implementation of the key recommendations of this paper should deliver the following benefits:

1. **Effective learning** - Intervention is about developing virtuous cycles of learning, tailored to individual needs
2. **Deep insights** – using deep analytics, new and unpredicted patterns can be found that can help inform decision makers about where to focus investments
3. **Timely intervention** – whilst E-Assessment takes essential “rear view mirror” snapshots of learning performance, predictive analytics can be used to constantly steer students in the right direction, maximizing the chances of doing well in assessment and examinations

3 interdependent processes combine to deliver a personalized learning experience:

- Assess
- Analyse
- Intervene
Ongoing assessment from a range of sources is used to gather data about how individuals and groups of students are learning. This data is analyzed to help target students with tailored learning, and to make decisions that lead to increased effectiveness. Using data, interventions can be set up to deal with issues such as reducing drop-out rates; selecting the most effective ways of improving reading and mathematics; and dealing with risks before they become a problem. Ultimately interventions can be tailored for individuals and groups of students.

Each of these processes are interconnected in multiple ways -

Let us now examine each function in turn.
1 ASSESS

E-Assessment is the foundation on which a personalised learning experience is built. This takes many forms from self-assessment to automatically assessing progress; diagnostic support; to public examinations. These functions can be formative or summative, low stakes or high stakes.

E-Assessment has come a long way in a very short time and it’s clear that Cloud technology is changing the game here - not only enabling lower cost of service, but also opening the possibility of global E-Assessments, with Assessment and Examination Boards being able to offer their services to anyone on the planet. With the advent of better biometrics, and new ways of supervising assessments, the most exciting prospect is the notion of assessments and examinations being available at any point in one’s lifetime.

There are a number or drivers behind the move towards E-Assessments and E-Examinations:

- **Cost** – the English examination system cost ~ $1bn in 2009. Much of this is tied up in paper-based processes – printing, delivering, collecting and scanning papers.
- **Flexibility** – the potential for going beyond what students can physically write on a paper.
- **Speed and accuracy** – the time from sitting the assessment to getting an accurate the result in front of those who need to know is compressed with E-Assessment.

The E-Assessment has 4 main components:
Within each of these functions are sub-functions:

![Diagram showing sub-functions of Prepare, Deliver, Mark, and Report]

**Figure 3. Assess sub-functions**

### 1.1 Prepare

#### 1.1.1 The Assessment Preparation Process

A key starting point in E-Assessment process is to prepare the assessments. These can range from quick, informal quizzes (for example pop-up questions), to terminal examinations – high stakes and requiring high levels of security.

Ideally, reusable combinations of test items are stored in a central database. Classification, the use of metadata and sophisticated enterprise search, makes it easy for editors to locate retrieve and package items. The smallest digital objects can be independently used or combined together to form test items.

Extending this further still, in the model below the central repository is connected to external assessment item publishers, online assessment item market places and the worldwide web. It exploits Cloud technology to drive out infrastructure and management costs; enable flexible scale; and increase reliability and speed.

1. Publishers research and develop new testing packages and make these available for different learning styles
2. Teachers look for tests for specific assessment opportunities, and assemble objects into packages for students

3. Teacher assigns assessment to students

4. Students undertake assessments individually or in groups

5. Students submit their assessment work

6. Feedback and new items get added to the assessment item repository

7. The repository receives other items through online market places and the web

8. Standards and processes are overseen by assessment committee which uses feedback data to make decisions about future tests.

Figure 4. The process of preparing assessment materials
<table>
<thead>
<tr>
<th>Key Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Expressions</strong> and <strong>Visual Studio</strong> - used extensively by professional assessment item developers.</td>
</tr>
<tr>
<td><strong>Microsoft Learning Content Development System</strong> (LCDS) - a free tool that enables users to create interactive, online courses and Silverlight learning objects. It can be used to create highly customized content, interactive activities, quizzes, games, assessments, animations, demos, and other multimedia.</td>
</tr>
<tr>
<td><strong>PowerPoint</strong> - the most widely used content creation tool in schools, and many schools create highly interactive and challenging content with it.</td>
</tr>
<tr>
<td><strong>MediaWiki extension for Word</strong> - allows learning materials developed in Microsoft Office to be saved directly to MediaWiki-based repositories such as WikiEducator.</td>
</tr>
<tr>
<td><strong>Hunterstone’s Thesis “Light”</strong> - create SCORM objects with relatively low levels of technical skill. Available as a free download with Learning Essentials for integration into Microsoft Office</td>
</tr>
<tr>
<td><strong>SharePoint Portal</strong> – assessment content developers can quickly find the content they need, consume and create new assessment items with others, and publish E-Assessments to a wider connected learning community.</td>
</tr>
</tbody>
</table>
1.2 Deliver

This functional area involves delivering the assessments to the end users – e.g. students sitting low stakes tests or high stakes examinations.

1.2.1 Example E-Assessment Processes

1. Exam/Assessment Board produces and signs-off assessment content collaboratively.
2. Assessment content is pushed into the Cloud and distributed via a Content Delivery Network.
3. Assessment content is cached at school/exam center level after the first student has viewed a particular resource.
4. For high stakes assessment, just before the assessment starts, policies are enforced on the candidate’s client computer, and the assessment content is cached either in a dedicated application or on the browser. The candidate’s response data is cached locally and periodically sent to the Cloud via the school level cache.
5. In the Cloud, the candidate’s data sits in a queue, and is then stored in flat tables.

Figure 5. Delivering E-Assessment at scale using Cloud technologies
6. Encrypted data from the Cloud is sent to a data center for longer-term storage and processing and in relational databases. Once all of the candidate’s response data is taken from the Cloud to the data warehouse, and the Cloud application is stopped.

7. Markers grade the work and ensure leveling and normalisation.

8. Results are collated, reported and analysed.

9. Results are passed on to relevant agencies for recognition and certificate distribution.

Another approach to delivery of high stakes assessment being considered by some is VDI. The ability to be able to push a virtual assessment desktop to a device and lock it down is appealing as it is potentially a simpler approach.

E-Examination is in its infancy, but many leading examination and assessment authorities are looking carefully into what’s next in this space.

1.2.2 Pushing Assessment Item Boundaries

Electronic tests and examinations can go way beyond what can be done on paper. There are three key areas where exploiting technology can have impact:

**CAT**

Computerised Adaptive Testing (CAT) is a form of computer-based test that adapts to the examinee’s ability level. For example, Medical students at St George’s, University of London using CAT based e-Assessment tools are asked to make decisions along a branched narrative in which information and choices available at a later stage depend on the choices the student made earlier.

ACARA – the Australian Curriculum and Assessment and Reporting Authority – takes this a step further and are working on providing candidates with branched routes through the assessment so they get appropriate recognition for what they have learned. A student who struggles with a question or task can be routed along a less demanding pathway, whilst a more able or better prepared student can be routed along a more demanding pathway – both are able to get the best out of the assessment process. Test-takers also do not waste their time attempting items that are too hard or trivially easy.

**Simulations**

The New South Wales DEC were able to exploit interactivity when they ran their science tests online. Being able to use interactivity in an assessment opens up a wide range of testing options – for example, asking candidates to build or construct something, conduct virtual experiments, use haptic to test dexterity, or develop an animated scenario. None of these options are practical in a paper and pencil assessment.
Assessing 21st Century Skills

Whilst we will see paper-based assessment for a long time yet, the pressure is on to find ways of assessing 21st Century skills such as creativity, problem solving, communication and collaboration. Problem Solving is now part of PISA 2012 framework. ATC21 – the 21st Century Skills assessment project – is doing some very interesting work in the area of collaborative assessment.

One thing is certain – pencil and paper testing won’t help much in diagnosing and assessing whether students have acquired 21st Century Skills or not, so it’s reasonable to conclude that E-Assessment has a big future.

1.2.3 Risks and Security

Whilst the benefits of E-Assessment are clear, there are significant security and risks concerns that should be noted. These range from academic dishonesty to technology vulnerabilities.

Academic Dishonesty

Some common academic dishonesty practices are:

- **Plagiarism** – using another person’s words or ideas without appropriate citation conventions as presented. This is a form of misrepresentation – falsely representing oneself, efforts, or abilities.
- **Fabrication** – making up data, results, information, or number, and recording, and reporting them as authentic work; and / or manipulating research, data, or results to inaccurately portray information in reports in one’s favour
- **Copying** – the direct transcribing of another one’s work as one’s own.

Classroom Management Software can play a role here too. For example, Windows MultiPoint Server 2011 provides capabilities that allow teachers control over student devices – from E-Assessments, to direct manipulation of student’s device. Teachers or invigilators can make use of easy-to-use tools to orchestrate and manage students’ use of computers, and help students stay focused on their E-Assessments.

For instance, thumbnail views in MultiPoint Manager give them an instant view of each student’s desktop. To get a closer look, they can zoom in on an individual student’s desktop. If they want everyone to see the same thing, they can broadcast a screen to the entire class. Teachers can also block all station activity, open and close applications, and restrict internet access to specific web sites relevant to the particular assessment.

Another example is Turnitin.com (previously known as Plagiarism.org) which searches the entire web and its own vast database for word sequences identical to those in a submitted paper.

Verification of students – i.e. “I am who I say I am” – is an important part of maintaining honesty in assessments, and biometric technologies can be used to confirm that students are who they claim.

Privacy screen filters can be used to prevent students from direct visual copying of information from another student. The use of Information Rights Management, described in the subsection below, can prevent the copy / paste of information that is shared electronically.
Technology Vulnerabilities

Information can always be intercepted and examined be it authentication credentials or sensitive student data transmitted upstream. Identity can be falsified, and information that shouldn’t be copied often is.

We recommend leveraging Microsoft Live and or Windows Azure Active Directory for the integrated authentication requirements. This can simply be achieved by subscribing to Microsoft’s Identity as a Service offering. Identity Management is about providing a single sign-on infrastructure – to store and map user credentials and access rights to information, allowing users and applications to connect to back-end systems (either on-premise or cloud hosted).

We recommend the encryption of information by leveraging the Microsoft platform on all devices – not only servers, but also devices such as tablets and mobile phones. The platform offers a variety of security options, giving IT support, a number of ways to help secure a device, including new Exchange Server policies and certificate options, storage card encryption, and continued support for remote and local device wipe.

We also recommend the use of Information Rights Management (IRM) to control how shared information can be used. A teacher may need to share notes, or sample answers to students but can restrict the use of the information. Information can have an expiry date, restrictions can be placed on how it can be shared to others, or even if it can be printed. This is ideal for organisations needing to prepare and distribute examination or assessment papers.

We recommend incorporating the Microsoft Security Development Lifecycle (SDL) to not only address compliance, but also thwart potential attacks and hacks. The Security Development Lifecycle (SDL) is a security assurance process that is focused on software development.

This contrasts with Open Source software. If the source code is available publicly, then constant efforts have to be made to secure it. The no ownership nature of Open Source poses other vulnerabilities too with regard to the possible inclusion of code that infringes copyright or patents.

1.2.4 Exploiting the Cloud

Cloud based content management technologies enable these processes to scale to national and even global levels. Core technologies that enable this are Azure and SQL Azure, with the following features are exploited:

- **Compute** is a service which runs managed applications in an Internet-scale hosting environment.
- **Storage** stores data including blobs - large binary objects, such as videos and images.
• **AppFabric** manages users’ permissions and authenticated use of web applications and services, integrated with Active Directory and web based identity systems including Windows Live ID, Google, Yahoo! and Facebook.

• **Content Delivery Network** - places copies of web objects (images and scripts), downloadable objects (media files, software, and documents), applications, real time media streams, and other components, close to users enabling high speed services.

![Figure 8. Azure Content Delivery Network](image)

• **Marketplace** - data, imagery, and real-time web services from leading commercial data providers and authoritative public data sources. The Windows Azure Data Marketplace will also contain demographic, environmental, weather and financial datasets. An Application Marketplace will enable developers to easily build E-Assessment applications for Azure.

**SQL Azure** can also be exploited to provide the following services:

• **Database** – relational database, providing services to multiple organisations.

• **Data Sync** – synchronisation between an organisation’s current SQL on-premises databases and SQL Azure Databases in the Cloud.

• **Reporting** – a complete reporting infrastructure that enables users to see reports with visualizations such as maps, charts, gauges, sparklines etc.

**Key Technologies**

• **Silverlight** - a great way for learners to experience E-Assessment content. A free, cross-platform browser plug-in, Silverlight is designed for Web, desktop, and mobile applications - online and offline. It supports multimedia, enhanced animation, webcam, microphone, and printing.

• **THESIS Librarian** - a MS SharePoint based SCORM repository that can be used for storage and delivery.

• **Biometric Hardware** – e.g. fingerprint readers

• **Windows Multipoint Server**

• **Windows Azure**

• **SQL Azure**
1.3 Mark

1.3.1 The Marking Process

This can range in sophistication according to the type of assessment from automatically marked assessment items, to scripts requiring the judgment of experts. Where human intervention is required, moderation (ie the normalisation of standards between assessors) is usually required, so the key technologies that are needed are communication and collaboration, and content management with rights management.

Content management is key to effective collaboration for both marking and preparation, and this requires the following functions:

- Document Management
- Collaboration (team sites), Extranet
- People Search
- Content Search
- Social Computing – including wikis and blogs
- Publishing Portal (custom theming/branding)
- Rich Media Management
- Data Visualization
- Workflows

**Key Technologies**

- **Office 365** provides a suite of communication, collaboration and storage services for assessors to communicate and collaborate. It also provides a single account and password for access to many Microsoft Cloud services including **Windows Azure**.
- **SharePoint Online**, which offers a core set of Content Management capabilities in the Cloud
1.4 Report

1.4.1 Providing Prompt and Accurate Feedback

Teachers invariably understand the value of giving immediate feedback. The longer a learner thinks that a wrong answer is right, the harder it is to correct. Put another way, the longer a learner waits for their work to be marked, the less efficient the learning. Therefore a key goal for providing feedback is to give it as close to immediately as possible.

![Figure 9. Old style reporting - highly ineffective](image)

Reporting on paper is a time consuming activity and can be highly inconsistent in terms of quality and accuracy. Paper based reporting usually flags problems long after something they happen, and is therefore highly ineffective.

1.4.2 Reporting Tiers

There are three areas where E-reporting can save time and money, and provide more immediate and helpful feedback:

- Reporting assessment results ‘upstream’
- Reporting back to students
- Reporting to shareholders
First of all, there’s the reporting of assessment results upstream in the schooling enterprise –

Secondly, there’s reporting back to the students who have sat the assessment. In high stakes testing one problem is to give all candidates their grades simultaneously. In Columbia, for example, The Instituto Colombiano para la Evaluación de la Educación (ICFES) administers standardised tests to students and has used Cloud technologies to reduce costs and better manage online queries when scores are posted. ICFES moved to a Windows Azure platform, cut costs by 80% and provided students a faster and more reliable solution.

In another example, the Lumiar Institute in Brazil developed a Learning Management System called “Mosaic” to help students and their teachers make decisions based on continuous assessment about where to spend their learning time.

Mosaic has three key basic components:

- A Competency Matrix—the curriculum of Lumiar School.
- A Project Database. Students develop competencies by working on projects, and the Project Database establishes “how” they will learn.
- The Learning Portfolio is the learning roadmap of students at Lumiar, and helps guide them to the projects that best match their learning needs.
Finally, there’s reporting to parents and other stakeholders. For example, Charlotte-Mecklenburg Schools use BI and SQL reporting tools to place dashboards online. Staff spend 45% less time dealing with data requests and therefore can devote more time to other valuable activities.

**Key Technologies**

- **Microsoft® SQL Server Reporting Services** enables detailed reports, dashboards and benchmark comparisons for individuals, faculties and departments. Create comparative reports on student performance.
- **Windows Azure**
2 ANALYSE

E-Assessment generates huge amounts of data, and within this data is extremely valuable information which can be turned into insights. An analytics capability can provide decision makers with predictive analytics, automated workflows, and Enterprise Resource Planning capabilities to:

- Improve student performance
- Make better management decisions
- Increase accountability
- Manage resources more effectively
- Drive administrative efficiencies

Most data in schooling systems is used to look backwards. Assessment results, for example are used in this way – to give a retrospective view of student performance. This “rear view mirror” approach misses the true value of analysing data.

Providing the right information to everyone in your school or district in a cost-effective way is potentially a major challenge. Meeting this challenge, however, can bring enormous benefit.

Figure 12. Most analytics gives a “rear view mirror” perspective

With the right tools, data can be used to make predictions and make smart decisions for the future. Used in the right way, analytics can be used to take corrective action before problems
materialise. For example, rather than looking just at examination data retrospectively, analytics allows decision makers to set up the conditions that optimise student’s chances of success in examinations *long before they sit them*.

![Figure 13. The point of analytics is to give a forward perspective](image)

To drive performance, as opposed to fighting fires, the ability to analyse results and plan for improvements is fundamental. Analytics enable schooling system managers to drive performance in 5 key areas:

- **Academic** – drive improvements in student learning results
- **Operational Excellence** – return on investment, value for money, staff retention, graduation rates
- **Stakeholder Satisfaction** – parents, students and staff satisfaction indicated by demand for places and posts at the school
- **People** – a motivated and prepared workforce
- **Building Management** - carbon reduction contribution from areas of the school buildings, energy use, U-values, temperature variation with sunshine and usage variation, cost analysis, efficiency, water use, electricity generation and area occupation and use.
2.1 Analytics Sub-systems

To make ever better management decisions requires the following systems:

**People**
- Organisation-wide access to relevant information
- Easy-to-use intelligence tools for all levels and roles
- Role-based delivery of performance-related information

**Processes**
- Scorecards, dashboards, and strategy maps that identify performance drivers
- Standardized KPIs to align with goals and initiatives
- Redesigned processes to affect performance drivers
- Automated workflow for simpler consolidation and reporting

**Technology**
- Data integration to combine information from existing systems
- Data consistency, security, and integrity

Brining these together, the Analyse process has four key components:

![](chart)

2.2 Collect

A schooling system will collect data from assessment and operations such as HR, transportation, food services, and estate maintenance.

The key reason to collect data is to understand and drive better performance. Performance data can be used to help individual children learn; for staff development purposes; tackling underperformance; transmitting knowledge about good practice; teaching and learning. In schooling, performance data can be categorised as follows:
Academic: E.g., test scores, exam results or competencies attained; Longitudinal data – i.e. student information collected over multiple years in multiple schools. Assessment data is a vital part of a teacher’s toolkit. It greatly informs professional judgement about learning and student support so every child can do their best.

Behaviours: incident logging for both good and bad behaviour, progress rates, targets met and failed, peer-to-peer report logging, behaviour analysis patterns, health information, secure access to health and social services data, such as medication and home situation, alerts, access, and catering.

Teaching: Academic performance in different subject areas or by teacher

Management: How well is the institution managed as indicated by absenteeism, stakeholder satisfaction, enrolment, dropout and graduation, expenditure per student

Research: Data and models from the latest academic research

With sufficient data, managers can ask “what if” and model solutions to problems. E.g.: if poor behaviour can be correlated to geographic areas within the school and times, then controls can be put in place to rectify it.

Data is inputted through integration with existing systems and InfoPath E-forms; SharePoint Surveys; and e-assessment applications. Custom applications – e.g., mobile phone based inspection systems - are also be used for data input.

Figure 14. Data comes from three main sources
### Key Technologies

- **InfoPath** can be used to publish forms and enable people to submit data easily
- **SharePoint Surveys** – built-in tools for collecting data in survey formats
- **BizTalk Server**, an integration and business process server that provides the process choreography between various sub systems
- **Windows Communication Foundation** (WCF) - remote procedure calls
- **SQL Azure Data Sync** enables creating and scheduling regular synchronizations between SQL Azure and either SQL Server or other SQL Azure databases.

### 2.3 Manage Data

Data management is fundamental to operating schooling systems. Without well managed data, schooling systems would grind to a halt – teachers wouldn’t get paid; students wouldn’t get transported, taught and fed; and essential services would cease to operate.

As the value of good data for decision making is becoming more widely understood, the quantity of data in the world’s schooling systems is ballooning. Much of the data that is growing exponentially is unstructured content, which needs to be considered in a data management strategy.

![Graph showing exponential growth of data](image)

*Figure 15. The amount of data in schooling systems is growing exponentially*

Key data management functions include Storage, Search, and Retrieval.
These functions are delivered within a three tiered architecture:

![Three tiered Analytics architecture](image)

Figure 16. Three tiered Analytics architecture

As the quantity of data generated increases, the justification for using Cloud technologies increase too.

### 2.3.1 Exploiting the Cloud

**SQL Azure** is Microsoft's Cloud Database solution, and it offers the following benefits:

- No physical administration required – software installation and patching is included, as SQL Azure is a platform as a service (PAAS)
- High availability and fault tolerance are built in
- Simple provisioning and deployment of multiple databases
- Scale databases up or down based on business needs
- Multitenant – i.e. a single database can provide services to multiple organisations
- Integration with SQL Server and tooling including Visual Studio®
- Support for T-SQL-based familiar relational database model
- Option for pay-as-you-go pricing
The SQL Azure suit comprises of the following offerings:

- **SQL Azure Database** – a Platform as a Service (PaaS) relational database. Highly available and scalable.
- **SQL Azure Data Sync** – allows organisations to extend their current sets of data into the Public Cloud. It provides synchronisation between an organisation’s current SQL on-premises databases and SQL Azure Databases in the Cloud.
- **SQL Azure Reporting** – a complete reporting infrastructure that enables users to see reports with visualizations such as maps, charts, gauges, sparklines etc. Currently available in Community Technology Preview.

**Key Technologies**

- Windows Azure
- SQL Azure
2.4 **Analyse**

Analysis capabilities enable you find out what contributes to or detracts from learning results and operational effectiveness. High quality analysis will show correlations between behaviours and results – for example, what are the causes of students dropping out of school early, or what effects do Circadian Rhythms have on examination results.

Visualisation tools such as dashboards and scorecards managers can create reports with maps, charts, gauges, sparklines etc. This provides managers with the ability to know “what is happening” and “what has happened” across the organisation.

Traditionally, these kinds of tools would be requested from the IT department, but there is a growing trend towards self-service Business Intelligence (BI).

![Figure 17. BI is moving to a Self-Service model](image)

### 2.4.1 Data Visualisation

Access to decision making information, combined with the ability to view and interpret the data graphically, enables identification of trends or potential outcomes that can be proactively managed.
**Tiered views**

Generally, education data views are most impactful when they can be provided as a high-level aggregate summary, such as at the school district level, then broken down into organizational and operational components. For example, a school principal may have a view displaying a summary view of standardised assessment results by level. It should be easy expand the view, showing multiple levels of information, such as assessment outcomes by school, class, teacher, period or student.

**Geo data**

Location or “Geo” data can be used to visualise school buildings, neighbourhoods, attendance patterns, transportation systems, emergency services, etc. providing stakeholders with a pictorial representation of school district data and administration.

**KPIs**

A KPI gives a summary definition of a specific data point, such as attendance. Progress against KPIs is generally visualized in the form of a target value, actual value, a status indicator of actual performance vs. target goal, and optionally, a trend indicator that defines progress towards or away from the goal.

**Scorecards**

Illustrate a collection of KPIs for a specific data point across multiple organizational units, such as schools or classes. Scorecards are used to easily access and compare the performance or status of organizational units.

**Dashboards**

A collection of scorecards showing multiple data points, that when combined, provides a summary view of varying elements. The user has the capability to drill down on a specific data element to grain greater insight into overall organizational performance.

**Reports**

Detailed views of data and information typically summarised into groupings of KPIs. Depending on a user’s role, reports may include drill down capabilities allowing the user to disaggregate information from the dashboard view. For example, when a district-level administrator wants to further understand a certain condition, such as declining attendance at a particular school, he/she can select that school’s attendance KPI on a scorecard, and then easily open and access a detailed attendance report for that specific school.

With sufficient information in the system, it’s possible to perform a range of analytical functions including grouping students together according to key attributes.
2.4.2 Business Intelligence

Business intelligence (BI) is a broad category of application programs and technologies for gathering, storing, analysing, and providing access to data from various data sources, thus providing enterprise users with reliable and timely information and analysis for improved decision making. BI is an umbrella term that refers to an assortment of software applications for analysing an organization’s raw data for intelligent decision making for business success. BI as a discipline includes a number of related activities, including decision support, data mining, online analytical processing (OLAP), querying and reporting, statistical analysis and forecasting.

Key Technologies

- **SharePoint Insights** - which features interactive dashboards and scorecards.
- **Excel Web Services (EWS)** - a Web service hosted in Microsoft SharePoint Services that provides several methods that a developer can use as an application programming interface (API) to build custom applications based on the Excel.
2.5 Plan

This capability provides the organisation with the ability to model what should happen, and conduct essential planning, budgeting, and forecasting exercises. These processes allow managers to align groups and individuals around the metrics that drive the organisation — for instance: “what should our examination result targets be?” or “what are we spending versus our budget?”

The planning function is about driving efficiencies and effectiveness through better targeting of resources through Enterprise Resource Planning in the following areas:

- Financial management
- Supply chain management
- Performance management
- Business intelligence
- Project management
- Human resource management
- IT management

Managing schooling systems is a complex business extending way beyond just the classroom. For example, teacher workforce development; transportation systems; lunch and nutritional programs and student medical welfare are all within the domain of schooling systems and dependent on the best decisions being made.

“While planning is an essential practice, it is un-nerving how few of us are able to do it effectively. The typical enterprise utilizes “10 general ledger systems, 12 different budgeting systems, 13 different reporting systems,” and takes “6 months for planning, 5 months for budgeting, 2 weeks to develop a forecast.” Such disparate information and slow execution make the basic practices of performance management a real challenge for most organisations” (Bruno Aziza, Joey Fitts, Driving Business Performance, 2008).

**Key Technologies**

- **Dynamics CRM** – services scheduling
- **Dynamics AX** – Finance; procurement; HR; relationships; projects and grants
- **Dynamics GP** – Compliance; supply chain management
- **Dynamics NAV** – BI; project and service management; budget and purchasing
3 INTEVENE

Learning can be said to be ‘personalised’ when students have a unique set of pathways through their learning. Clearly, at early stages younger learners need a lot of adult support with learning decisions, but as they progress through their schooling they need to become more independent - and that independence can be supported with technology.

To personalise the learning experience students' progress should be continually assessed - as unintrusively as possible - and their learning pathways should continuously evolve over time. This relies on highly effective feedback loops and systems which dynamically adapt to the twists and turns of the learning process, and set challenging learning goals and tasks. The core process is to place learners into groups according to what they need to learn or do; then step them through a series of linked actions until the goal is reached; then use data to make ever improving interventions.

This is extremely difficult to do with a paper-based approach, but can be made a lot easier through using IT systems that provide analytic and workflow capabilities. The benefit for the teacher is that their administrative burden is reduced. The benefit to the student is that they get a learning service better customised to their specific needs.

In the same way as data can be used to identify and treat health problems before they become an issue, intervention in education is about preventing issues developing into major problems. For example, the Intervene capability can assist schooling systems identify students that show the early warning signs associated with disengagement from school, and therefore help reduce dropout – currently estimated at costing $2m per student in the European Union.

The core technology for intervention is CRM. Derivatives of CRM – known as XRM solutions – have been developed for a range of sectors. In healthcare for example XRM is used for a range of activities such as notifying patients of upcoming appointments and how to manage their illnesses.
Student Relationship Management (SRM) has been extensively used in Higher Education for a long time for a variety of purposes – e.g. implementing targeted marketing campaigns to prospective students and alumni. SRM is used in HE to support enrolment and to track financial matters such as the payment of fees. For similar reasons, SRM is also used extensively in private schooling.

In Brazil, Gestar — an independent software vendor — built an SRM system for private schools that not only handles the administrative "mechanics", but academic matters too. The objective was to apply the concepts of “marketing one-to-one” to the complete relationship cycle with students – from the initial recruiting process to completion of school and beyond. By gathering and using the information generated in Management Information System (MIS) and Learning Management System (LMS) – e.g. attendance and individual assessments – it was possible for the schools served by Gestar to improve their effectiveness.

In schools using the Gestar SRM system, dropout rates are reduced by cross-checking data across a range of “risk factors”. This makes it possible to identify students at risk of dropping out, and this automatically triggers processes such as setting up interviews, identifying the causes of dissatisfaction, and aligning the student’s objectives with what the school can offer.

Through linking with the Learning Management System, SRM is able to determine if students are accessing the e-Learning tools, completing assignments within given deadlines, and if they are satisfied with their learning activities. Through automated workflows, Intervention can be used to address specific problems.

Pre-defined workflows and escalations, in some cases completely automated, make it easier for a teacher to be more “granular” in how they address students’ individual needs – hence the ability to deliver a more personalised learning model.

There are four key steps in the Intervene process:

- Assess
- Design
- Run
- Pathways
3.1 Assess

The first phase of the Intervene process is to assess students. Ideally, this will be happening on a permanent and ongoing basis through the Assess function. Added to that a combination of learning and operational data will be constantly fed into a central, integrated student record.

The goal of Intervention isn’t to just react to a string of unrelated scores, but rather to tackle deeper personal needs through addressing a range of student attributes. At the heart of the SRM is the student profile. This builds up over time and as more data is added, the smarter the interventions can get.

All stakeholders should have role-based access to a single place to capture and view marks/comments on students. To make this easier to manage, the centralised student record should contain all relevant data for each student.

**Academic**

- Learning Styles
- Individual Learning Plan
- Links to e-Folios
- Targets
- Performance
- Feedback

**Organisational**

- Attendance
- Behaviour
- Catering
- Transportation
- Access – who is permitted to go where
- Risk profile - a set of indicators that show real or potential problems that require intervention
Personal

- Name, Address, etc
- Photo
- Contacts
- Health information
- Social background information

Contextual knowledge such as peer feedback, socio-demographics and friendship groups can also be used.

Key Technologies

- Dynamics CRM
- SQL Reporting Services
- SharePoint
- Excel

3.2 Design

The next step in the Intervene process is to set up "risk factors" that may affect learning performance, finding students who fit the risk profile, and then intervening through goal orientated actions. If, for example, that a school has found that those students with the lowest reading ages perform the worse in examinations, then clearly reading age can be considered a risk factor. The same could be said for other attributes such as attendance, behaviour, or socio-economic factors.

With sufficient amounts of high quality data in the system, Intervention can help correlate factors that affect learning with individuals or groups of students. For example, low reading ability at an early age may be an indicator of future test/examination results. An Intervention here would involve identifying the children who have the lowest reading abilities and providing them with additional reading support.

Other examples include:

- Recommendations for additional learning resources, based on analysis of attainment results and learning style.
Interventions can be set up to help broaden the student’s social and educational horizons based on analysis of student interests and friendship groups.

Health and wellbeing alerts based on analysis of foodstuffs bought via cashless vending, and correlated against attendance and attainment.

With the risk factors established, the next step is to set up the “triggers” – i.e. the thresholds above or below which a student should be at for their particular grouping. From there, it’s a matter of designing the Intervention process through a series of automated workflows.

**Key Technologies**

- **CRM** – automated workflows
- **SharePoint** – automated workflows
3.3 Run

To illustrate how Intervention works, let’s explore the ‘reading age’ example further. Using Intervention a teacher could run a report to identify all students with a reading age in excess of 2 years below their actual age. Armed with this data, the teacher can now trigger a whole set of automated events and escalations – e.g. getting students to reading clubs; persuading parents to encourage more reading at home; asking teachers to give extra reading support where needed etc. To do the same analysis and run the intervention programme using a paper based approach would be extremely resource intensive.

Figure 21. Example intervention process - based on tackling low reading age
3.3.1 CRM in Teacher Training

A different example of how Intervention can be exploited in schooling systems is in the area of professional development. In Maryland, USA, the State Education department used CRM to improve administration of certification. At any one point in time, there will be 160,000 people in the Maryland State Education System requiring certification of one kind of another. Overwhelmed with a backlog of requests processing times for new certificates extend to as long as 18 months. Maryland introduced a CRM system that reduced certificate-processing times to as little as five days and virtually eliminated dependence on paper.

3.3.2 Scaling Interventions

There is technically no reason why an intervention – say for absences – can’t be deployed across multiple schools. If the risk factors, triggers and processes are the same or similar, then a centralised system could potentially manage interventions across several schools simultaneously.

Take for example, the issue of dealing with students not turning up to school on time. This is a common problem across all schools regardless of geography. If each school intervenes individually, there are duplicated processes repeated multiple times across the schooling system.

On the other hand, centralising the data and managing the lateness process can reduce duplication and workload. Once a certain threshold has been reached, so will trigger a set of automated escalation to the relevant people processes requiring little human intervention. The gain here is not only driving out low value processes but the prevention of costly problems.

Figure 22. Pooling interventions to save resources
The more schools are contributing data to understand risks and how best to deal with them, the better. The more data, the more variables can be considered and the richer the decision making process.

3.3.3 XRM

Dynamics CRM is a Customer Relationship Management software package. The product focuses mainly on Sales, Marketing, and Service (help desk) sectors, but the Dynamics CRM is highly customizable through the .NET framework. When it’s used for managing relationships with groups of people other than customers (e.g., patients, or students) it’s known as XRM.

For example, iqDynamics, a company that provides IT Solutions in campus and student management, created an XRM system called StudentLink. Using StudentLink schools can build a modular student management system with the features they want. It offers solutions for Universities, Colleges, Independent Schools, Childcare and Kindergartens as well as Private and Commercial schools.

Modules offered include:

- Student Management
- Course Management
- CCA Management
- Academics
- Fee Management
- Student Online
- Facility Management
- School Analytics
- Class Management
- Teacher Management
- Library Management
- Financial Management

Intervention requires the capabilities of Business Intelligence that Microsoft SQL Server provides.

**Key Technologies**

- Dynamics CRM
- SQL Server
3.4 Pathways

The end goal of the process is for each student to have a personalised learning pathway. This is the route taken by a learner through a range of learning activities, which allows them to build competence and knowledge progressively.

Learning pathways reveal the learning trails that learners take through their assignments. Since learners have unique learning needs based upon their experiences and abilities, the routes they each take through learning tasks will vary.

A Learning Pathway serves as the student’s road map and sets out a plan of action and details the steps for completing his or her learning requirements.

It includes, for example:

- A summary of the student’s learning styles
- Knowledge, skills and competencies in need of acceleration/recovery
- A course of study map
- Courses needed for make-up credit
- Courses needed for graduation requirement completion
- Courses needed for post-secondary acceptance
- Special needs
- All assessment measurements
- Work experience/community service goals
- Evaluation of grades

The Learning Pathway is continually updated and reviewed as the student progresses and forms the basis for regular updates with the student’s parents or guardians. Crucially, the Learning Pathway is less retrospective and more about making the right interventions at the right time to maximise the chances of success.

The Learning Pathway serves as a goal-setting and tracking tool. The Learning Pathway explicitly shows students how they can successfully complete the work required to succeed, and they can visually track their progress towards meeting their goals.
When connected to Learning Management and Content Delivery systems at a National level, Learning Pathways can be delivered at scale, personalising the learning experience for all students in the schooling system.

**Figure 23. Pathways through a curriculum with “competency meter”**

**Figure 24. Delivering Personalised Learning Pathways at Scale**
Key Technologies

- Windows Azure
- BizTalk
- Deep Zoom
- HTML 5 Dev tools – Expression Suite, Visual Studio
- SharePoint (Insights)
- SQL (Denali)
- SQL (Analysis Services)
- SQL Azure Reporting
- SQL Azure and Data Synch
4 ARCHITECTURE

4.1 Schooling Technical Architecture

IT Platform Architecture

In the above architecture, a personalised learning platform is the “anchor-point” around which the entire IT Platform is architected.
4.1.1 Connected Learning Community

Whilst there may be elements of learning that require independent work, learning only really acquires meaning in a social context, and the most immediate and direct social context for schooling is the local community.

ICT can be used to connect together all those who can make a contribution to students’ learning – e.g. local business, community resources (e.g. museums/libraries), parents and 3rd party learning services. It can connect students to inspiring individuals and inspirational speakers; promote debate and engagement between collaborators in face-to-face or virtual groupings; and provide mentoring opportunities. Connecting stakeholders together in a Connected Learning Community has enormous benefits such as engaging parents more deeply in the learning process, speeding-up processes and improving students’ connections with the outside world. The core of a connected learning community is a portal that can be accessed from anywhere.
4.1.2 Presentation Services

This is the user interface layer. This presentation layer is the interface for user experience and collaboration. Both the server and client systems need to be considered here:

**Client**

The client device provides the rendering of the content that is hosted by the server. There are two types of clients: the mobile phone device (referred to as Windows Phone), and the general purpose client, referred to as Windows 8. There's also an embedded Windows option for self-service kiosks.

Both Windows 8 and Windows Phone provide an enhanced user experience that supports dynamic content from standards such as HTML5, Silverlight, and JavaScript. Windows 8 adopts a Metro-style concept featuring live application ‘tiles’.

**Server**

Hosting and serving content is provided by a portal engine - SharePoint Server, a world class Enterprise Portal platform makes it easy to build and maintain portal sites for delivering content.

SharePoint Server provides a comprehensive application integration framework allows one to quickly assemble composite applications from existing systems. It delivers a rich development environment for assembling applications from services provided by line-of-business systems.

SharePoint Server also enables one to create rich, interactive business intelligence (BI) dashboards that assemble and display business information from disparate sources by using built-in Web Parts. These Web Parts include key performance indicators (KPI), Office Excel Spreadsheets, Microsoft SQL Server 2012 Reporting Services reports and a collection of business data connectivity Web Parts that can visualize information residing in back-end line-of-business applications.

4.1.3 Education Services

This set of functions defines the services that are delivered to each of the stakeholder groups in the Connected Learning Community via the presentation layer. These are built as Web-
services, SharePoint Web Parts and custom applications within a Services Orientated Architecture Service (SOA).

4.1.4 Schooling Enterprise Services

These services are server-based and support the web services delivered in the “Education Services” layer.

4.1.5 Cloud Based Schooling Services

Many Schooling Enterprise Services can be delivered through Cloud technologies.

4.1.6 Personalised Learning Platform

This is the core of the system and is made up of each of the Assess, Analyse and Intervene functions.
4.1.7 Core Infrastructure Services

Core infrastructure services underpin the Learning and Enterprise services. These are shared resources for all line of business applications on the server, such as user profile management from Microsoft Windows Server Active Directory services.

One of the most important uses of Active Directory is to provide a solid foundation to manage access to information, helping ensure that only approved users can access sensitive information.

Both Windows Phone and Windows 8 offer a set of important device security and management features that include the capability to remotely wipe all data from a device should it be lost or stolen, helping ensure that confidential information remains that way.

4.1.8 Cloud Infrastructure Services

Many Core Infrastructure Services can be delivered from the Cloud using the following technologies.

Public Cloud

Office 365 which includes the Microsoft Office suite of desktop applications and hosted versions of Microsoft’s Server products (including Exchange Server, SharePoint Server, and Lync Server), delivered and accessed over the Internet.

Microsoft Office 365 supports integrated authentication with the Windows Azure Active Directory – thereby supporting single sign-on requirements and providing a seamless user experience.

Windows Azure an application platform in the cloud that allows Microsoft datacenters to host and run applications. It provides a cloud operating system called Windows Azure that
serves as a runtime for the applications and provides a set of services that allows development, management, and hosting of applications off-premises.

**SQL Azure** - cloud database service built on SQL Server technologies. With SQL Azure, developers do not have to install, setup or manage any database. High availability and fault tolerance is built-in and no physical administration is required. SQL Azure is a managed service that is operated by Microsoft and has a 99.9% monthly SLA.

**AppFabric Azure** consists of the Service Bus, Caching, and Identity.

**Azure hosted Integrated Authentication** which enables an organization’s Active Directory to operate in the cloud.

**Windows Intune** - enables administrators manage and secure computers through cloud-based management and security capabilities through a single web-based administrative console.

**Private Cloud**
A Private Cloud shares many of the characteristics of Public Cloud computing including resource pooling, self-service, elasticity and pay-by-use delivered in a standardized manner with the additional control and customization available from dedicated resources.

Virtualisation based on **Windows Server** with **Hyper-V** is a good starting place for developing Cloud capabilities within a single school environment. At Local Education Authority (LEA) level and above we can start thinking about using virtualisation more extensively in Data Centres and start turning Data Centres into Private Clouds by packaging and managing services, and developing cross platform and cross environment capabilities.

A key differentiator between an ordinary Data Center and a Private Cloud solution is how services are packaged and managed. As organizations begin to move from virtualized infrastructure to private cloud implementations, their focus begins to shift from virtualisation to applications and services.

Designing and operationalizing sets of applications and services could potentially be complex, but **System Center 2012** enables a simplified and visual approach. The health and performance of all aspects of IT infrastructure, including the physical layer, the virtualization layer, the operating system and the applications need to be managed too, something that can be accomplished with **System Center Operations Manager**.

Services are rarely built from the ground up, so it’s critical to make sure that there is good interoperability between different system components, which can be layered in this way:

- Application frameworks – e.g.: Net; Java; php; Ruby
• Management – System Center; HP; CA; BMC; EMC
• Operating Systems - Windows Server; redhat; Suse; CentOS
• Virtualisation (multiple hypervisor management) – Hyper-V; Citrix; VMWare
• Hardware – HP; Dell; Fujitsu; IBM; NEC; Hitachi; Cisco

It’s unlikely that any education organisation is going to want to migrate everything to a Public Cloud immediately. Rather, organisations are much more likely to spread workloads across On-Premises, Virtualised Data Centers, Private and Public Clouds.

![Diagram showing application portability across traditional, highly virtualized, private, and public clouds](image)

**Figure 26.** Microsoft enables portability across a spectrum of computing options

### 4.1.9 Integration and Orchestration Services

Integration and Orchestration Services are provided by an Enterprise Service Bus, which delivers the following:

- **Brokered communication.** The basic function of an ESB is to send data between processes on the same or different computers. Like message-oriented middleware, the ESB uses a software intermediary between the sender and the receiver, providing a brokered communication between them.
- **Address indirection and intelligent routing.** ESBs typically include some type of repository used to resolve service addresses at run time. They also typically are capable of routing messages based on a predefined set of criteria.
- **Basic Web services support.** A growing number of ESBs support basic Web services standards including SOAP and WSDL as well as foundational standards such as TCP/IP and XML.
- **Endpoint metadata.** ESBs typically maintain metadata that documents service interfaces and message schemas.

Microsoft’s offering in this space is focused around **BizTalk Server**, an integration and business process server, and **Windows Communication Foundation (WCF)** remote procedure calls. BizTalk Server provides the process choreography between the various
systems that communicate within and outside of the e-Assessment system, and WCF is the inter-process communication interface.

In addition to being a hub for information exchange, the service broker could also broker service (command) requests. Business logic encapsulated within BizTalk orchestrations could be exposed as Web services, and messaging security can be provided by Windows Communication Foundation (WCF).

Information exchange among educational institutes/partners should eventually be achieved through federation of distributed service brokers.

The SOA adherent Enterprise Service Bus services, provided by BizTalk Server, and using WCF as the interface, can be used for inter-school communication between its own systems, and also with the Connected Learning community - including the Ministry of Education.
4.1.10 Key Interfaces

Data from E-Assessment will be used to inform a spectrum of decisions across the entire enterprise, so interfaces between the E-Assessment platform and other platforms are particularly important.

Figure 28. Connecting E-Assessment with other platform components

4.1.11 Services Orientated Architecture

The IT Platform should be modularized in a loosely coupled way. This requires:

- Clear guidance represented by a well-formed framework
- Standards and specifications that represent the whole process of assessment as well as communication. Between the services and components
- Cross-domain requirements analysis in order to define the specific requirements for each application domain
- Web services that provide the cross-domain requirements and interact through well-defined interfaces

The answer to these requirements is Services Orientated Architecture (SOA). The following example illustrates how Web services could be used to implement an enterprise SOA that integrates client applications and valuable data assets from across the enterprise.

![Figure 29. Web Services in an SOA](image)

In this example, the “Business Services” layer is implemented as a set of schooling enterprise Web services; the “Application Processes” layer orchestrated and aggregated the lower level services; the “Gateways” layer provided service gateways or adapters to connect to other systems; the “Implementation” layer consisted of the low level functional implementations.

A system based on a SOA will package functionality as a suite of interoperable services that can be used across the entire enterprise. Sub systems within an SOA interoperate through the use of communication methods based on industry-wide Web-service standards (e.g. SOAP). SOA can be used to guide design in each architectural domain as the overall solution design takes shape.
A schooling ICT system will have three main architectural “domains” – Software, Physical Infrastructure (hardware) and Information. The goal of SOA is to define architectures in terms of services. Each of these start at the conceptual level – i.e. the AFC mapping that we covered in the “Taming Complexity” section – before drilling down into logical and physical designs.

![Diagram of essential architectures](image)

The conceptual architecture summarises the overall design from the perspective of the user; the logical architecture shows how services work; the physical architecture shows how the hardware is configured.

In the Schooling Enterprise Architecture model, Schools are branch sites from the Local Education Authority hub and as such receive the full range of Schooling Enterprise Services.

Underpinning the IT infrastructure at the school and its “franchises” is a set of Core Software Services including Security, Identity, Comms & Collab, System Management and Directory services. Services are either delivered through on-premises servers or relayed from data centres, private and public clouds “upstream” at the Ministry of Education level.

### 4.1.12 Data Models

Interoperability between systems starts with data definition. The core sets of data that need to be defined here is that related to assessment. In order to design an effective choreography of information exchange, we must first look at data models. We start with a conceptual model to help us think through the requirements associated with assessment, and standardized testing.
**Conceptual Model**

The conceptual data model is essentially a set of technology independent specifications about the data. To build a report on how students have performed in a test, the following key pieces of data are required:

- School
- Teacher
- Student
- Assessment Result
  - Period (timeframe taken)
  - Grade (Score)
  - Grade (Text)
- Other
  - FRL
  - Ethnicity
  - English Language Proficiency

The conceptual model is then translated into a logical data model, which documents structures of the data that can be implemented in databases. Implementation of one conceptual data model may require multiple logical data models.
Logical Model

The logical data models represent the abstract structure of some domain of information. Once validated and approved, the logical data model can become the basis of a physical data model and inform the design of a database.

Figure 32: Logical model for standardised testing
**Physical Model**

The last step in data modeling is transforming the logical data model to a physical data model that organizes the data into tables, and accounts for access, performance and storage.

---

*Figure 33. Physical data model for standardised testing*
4.1.13 Design and Develop

Microsoft provides the platform for developing complex distributed applications, enabling the creation of robust systems, and reinforcing them security, management, and tooling functions.

![Diagram of the development environment for the IT Platform](image)

Figure 34. The development environment for the IT Platform

.NET is the Microsoft Web services strategy to connect information, people, systems, and devices through software. Microsoft provides equivalent cloud capabilities through its Azure set of offerings – that means software and custom development designed for on-premise infrastructure, can be leveraged for Azure.
## 4.2 Key Technologies Summary

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| Design | Services
|--------|-------------------------------|
|        | SharePoint
|        | CRM – automated workflows
|        | SharePoint – automated workflows
| Run    | Dynamics CRM
|        | SQL Server
| Pathways | Deep Zoom
|        | HTML 5 Dev tools – Expression Suite, Visual Studio
|        | SQL (Denali)
|        | BizTalk Server
|        | SharePoint (Insights)
|        | SQL (Analysis Services)
|        | BizTalk Server
|        | Windows Azure
|        | SQL Azure Reporting
|        | SQL Azure and Data Synch

**IT Platform**

**Student and Teacher Desktop**
- Desktop foundation: Windows 8
- Notes, comms & collab: OneNote
- Creativity: Learning Suite

**Content and Learning Services**
- Content Management Systems: SharePoint 2010
- Storage: SQL 2012, SQL Azure
- LMS: Desire2Learn

**Productivity**
- Productivity suite: Office 365
- Electronic grade book: PS, SQL 2012
- Learning apps and content: PS, SharePoint 2010
- E-Forms: InfoPath, SharePoint 2010

**Data Driven Decisions**
- Finance: Dynamics Suite
- Performance Management
- HR
- Student Relationship Management
- Enterprise Resource Planning
- Analytics and Business: SQL 2012 BI, SQL Azure

Prepared by Mike Lloyd with contributions from Quoc Bui, Horng Shya Chua, Puay San Ng and Edgar Ferrer Gil
http://edutechassociates.net
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**Communication and Collaboration**

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**Service/System Management**

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Table 1. Key technologies
5 IMPLEMENTATION

5.1 Increasing Sophistication

The goal of any long term IT Platform project is to increase the sophistication of the solution without adding layers of complexity. This can be achieved by building the Personalised Learning Platform within two nested frameworks – Schooling Enterprise Architecture, and Schooling Technical Architecture.

![Diagram of Sophistication of Solution over time]

**Figure 35. Increasing sophistication of solution over time**
5.2 Taming Complexity

Take a system with interfaces across the following 5 boundaries:

![Diagram showing interfaces in a data system]

Figure 36. Interfaces in a data system

If each boundary handles 10 different types of data, then roughly speaking there are $10^5$ (100,000) “sub-interfaces” that have to successfully connect to make the system function properly. The complexity increases dramatically when you add complexities such as data formats and exchange methods.

With each subsystem added to the solution, complexity increases exponentially, so it’s critical to have a method for turning complexity into sophistication.

Building ever increasing sophisticated solutions requires

- A container for complexity
- A 5 step solution development process
- A model for planning maturity levels

5.2.1 The Complexity Container – Schooling Enterprise Architecture

Enterprise Architecture is an industry standard for containing and managing all the components and relationships within large, complex systems. Enterprise Architecture (EA) is a 20 year old discipline, and is used to organise all the “moving parts” in complex organisations.

A domain specific version of Enterprise Architecture called “Schooling Enterprise Architecture” (SEA) was published in “Schooling at the Speed of Thought”. Schooling Enterprise Architecture is the container for all activities in a schooling organisation.
5.2.2 Five Step Solution Development Process

With processes established for developing and running the overall Schooling Enterprise through Schooling Enterprise Architecture, the next step is to set up the IT Platform Architecture component.

The process for evolving the IT Platform can be broken down into the following 5 steps:

1. Govern – a management model for the overall development process
2. Map – capturing and communicating each function and component in the system
3. Rationalise – grouping related functions/components and eliminating duplicates
4. Solve – Microsoft Solution Framework process for designing and implementing solutions
5. Move to Next Maturity Level
5.2.3 Move to Next Maturity Level

Whilst in any schooling system there are an infinite number of possible problems and opportunities, generally speaking these can be categorised as three main opportunity areas:

- Providing access to opportunities
- Making learning more effective
- Making operations more efficient

Each of these opportunity areas maps to four technology categories, giving a total of 12 strands of development:

- **Access**
  - Infrastructure
  - Devices
  - System Management
  - Support & Training

- **Learning**
  - Creativity
  - Team-working
  - Content
No school or schooling system will ever be in exactly the same place as another, so the concept of levels of maturity both helps contain complexity and enables planners to assess where an organisation is and plan how to move to the next stage. Generally speaking these can be categorised into four main phases: First Steps, Enhanced, Strategic and Transformed.

Mapping the opportunity and technology categories with maturity levels, we end up with the following matrix.

<table>
<thead>
<tr>
<th>Access</th>
<th>Infrastructure</th>
<th>Grid</th>
<th>Wireless</th>
<th>Pervasive Broadband</th>
</tr>
</thead>
<tbody>
<tr>
<td>Devices</td>
<td>Shared</td>
<td>Allocated</td>
<td>Personal</td>
<td>Ubiquitous and Varied</td>
</tr>
<tr>
<td>System Management</td>
<td>Classroom/Orchestration</td>
<td>Network Management</td>
<td>Automated</td>
<td>Predictive</td>
</tr>
<tr>
<td>Support &amp; Training</td>
<td>Basic concepts/new methods</td>
<td>Service Desk</td>
<td>Student Helpdesk</td>
<td>Pre-emptive Engineering</td>
</tr>
<tr>
<td>Learning</td>
<td>Creativity</td>
<td>Visual tools</td>
<td>Visual/Auditory tools</td>
<td>Problem Based Learning</td>
</tr>
<tr>
<td></td>
<td>Team-working</td>
<td>Productivity</td>
<td>Communication</td>
<td>Co-production</td>
</tr>
<tr>
<td></td>
<td>Content</td>
<td>Digitised Books</td>
<td>Multimedia</td>
<td>Interactive</td>
</tr>
<tr>
<td></td>
<td>Learning Management</td>
<td>VLE</td>
<td>E-Assessment</td>
<td>Intelligent</td>
</tr>
<tr>
<td>Operations</td>
<td>Resourcing</td>
<td>Reactive Resourcing</td>
<td>Targeted Resourcing</td>
<td>Decision Support</td>
</tr>
<tr>
<td></td>
<td>Managing the Institution</td>
<td>Monitor</td>
<td>Analyse</td>
<td>Plan</td>
</tr>
<tr>
<td></td>
<td>Data Services</td>
<td>Informed Judgement</td>
<td>Insights</td>
<td>Integration</td>
</tr>
<tr>
<td></td>
<td>Service Platform</td>
<td>Classroom Network</td>
<td>School Network</td>
<td>Community Network</td>
</tr>
</tbody>
</table>

With levels of maturity defined, the IT Platform can be developed through solutions projects through each maturity phase, according to prioritised needs.
5.3 Standards

Standards are important for consistency in data and process choreography. Consistency in content formation allows pedagogical software to create and render the content in a data structure that is universally understood. For example, if a teacher can create content in an accepted standard such as SCORM, using any vendor technology, then that content can be leveraged and even enhanced by another teacher, using a different set of vendor technology. This is similar in concept to HTML – a standard that is agnostic to technologies that create its content and those that render it.

Interconnectivity between systems requires accepted universal process choreography of data exchange. The Personalized Learning Platform is not a stand-alone system – it operates as part of a constellation of other systems such as content management systems, learning management systems, and student relationship management systems. An agreed upon set of data and process choreography standard is required. Interconnectivity systems need to provide a dependable set of information that is passed between each other, and address how the information flows, including managed error handling.

Standards such as Shareable Content Object Reference Model (SCORM) and Schools Interoperability Framework (SIF) are the main pedagogical compilation of technical specifications, and choreography blueprint, respectively. Microsoft supports both these
standards and recommends their adoption, as well as those from IMS Global Learning Consortium. Adopting standards is how systems can achieve interconnectivity.

**Schools Interoperability Framework (SIF)**

The Schools Interoperability Framework (SIF) began as an initiative chiefly championed initially by Microsoft, to create “a blueprint for educational software interoperability and data access.” It was designed to be an initiative drawing upon the strengths of the leading vendors in the K12 market to enable schools IT professionals to build, manage and upgrade their systems. It was endorsed by close to 20 leading K12 vendors of student information, library, transportation, food service applications and more. The first pilot sites began in the summer of 1999, and the first SIF-based products began to show up in 2000.

Traditionally, standalone applications used by public school districts have a limitation of data isolation; that is, it is difficult to access and share their data. This often results in redundant data entry, data integrity problems, and inefficient or incomplete reporting. In such cases, a student’s information can appear in multiple places but may not be identical, for example, or decision makers may be working with incomplete or inaccurate information. Many district and site technology coordinators also experience an increase in technical support problems from maintaining numerous proprietary systems. SIF was created to solve these issues.

SIF is not a product, but an industry initiative that enables diverse applications to interact and share data seamlessly. It is actively maintained by the specification body, the Schools Interoperability Framework Association.

The specification is composed of two parts: an XML specification for modeling educational data, and a SOA specification for sharing that data between institutions. The SIF Specification is an open standard that any technology providers or schools can develop to and implement. The Specification development process gathers the various stakeholders, from end users to developers, to ensure accurate identification of issues and solutions development for data requirements in today’s educational landscape.

**Shareable Content Object Reference Model (SCORM)**

SCORM is a compilation of technical standards and specifications from IEEE, IMS and AICC. The collection includes a Content Aggregation Model (CAM), Sequencing and Navigation (SN) and Run-time Environment (RTE).

**IMS**

There is a variety of other education technical standards – such as those led by IMS Global Learning Consortium. IMS (Instructional Management Systems) addresses a variety of needs, such as E-Folio, and Question and Test Interoperability (QTI) standards, for assessments. IMS QTI specifies a way of exchanging assessment information such as questions, tests and results using XML – extensible markup language.
BPEL

Another standard recommend for consideration is Business Process Execution Language (BPEL) for workflow related efforts, and Business Process Execution Language for Web Services (BPEL4W) for inter-process communication between systems. Middleware messaging engines and Enterprise Service Bus systems tend to adhere to this standard. Microsoft supports BPEL, BPEL4W, and its own variant XLANG with the AppFabric suite of products including BizTalk Server, Windows Workflow Foundation, and Windows Server AppFabric Host.
6 FURTHER INFORMATION

Schooling Technology overview - http://edutechassociates.net

E-Assessment http://edutechassociates.net/2012/03/05/e-assessment-the-high-stakes-strategy/


Assessing 21st Century Skills – http://www.youtube.com/atc21s

Cloud Technology white papers - http://www.davidchappell.com/writing/white_papers.php