Interoperability Standards for K-12 Education

BY THE COSN TECHNICAL COMMITTEE UNDER THE LEADERSHIP OF JOHN ALAWEH

K-12 institutions are increasingly looking to digital content and related e-learning technologies to meet evolving education needs and goals. Technology-based products, services and resources are having a positive impact on education and improving both efficiency and outcomes in the areas of teaching, learning, and classroom and school management. And yet, even as educators grow more sophisticated in their use of technology, there remain gaps in the integration and interface among disparate applications.

Historically, the case for interoperability – the seamless sharing of data, content and services among systems or applications – has not been compelling in the K-12 education marketplace. As long as programs were restricted to individual computers or small local area networks, the costs to developers of agreeing on and implementing comprehensive, industry-wide standards were rarely justified by the benefits. Many vendors chose, instead, to focus on proprietary designs that, while solving the needs of their customers, maximized their own profitability and did not allow for easy integration with systems from other vendors. Likewise, education decision-makers have traditionally been more concerned with locating products that meet their immediate local teaching and administrative needs than worrying about global data integration as a technical requirement.

Today, however, with the advancement of the Internet and the increasing reliance on digital delivery, the usability of isolated K-12 data, content, and learning applications is rapidly diminishing. The growing popularity of cloud computing has increased the need for interoperability standards that allow the customer to assemble multiple, cloud-based tools and services into a coherent whole. Interoperability is also a logical response to the increasing demand for online learning, data warehousing, sophisticated analytics, accountability reporting, and performance management tools. Education institutions are seeking to strategically leverage their content and data assets across a number of systems and assemble best-of-breed solutions that integrate content and applications from a variety of sources and vendors. For cost efficiencies, as well as teaching and learning effectiveness, interoperability standards are a necessary component of these emerging systems.

While early efforts at system integration frequently took a “manual” approach – with vendors customizing products for individual district needs – more comprehensive industry
interoperability standards are gaining momentum. “Plug and play,” in which applications from multiple vendors have the ability to exchange information automatically, without customization, is the ultimate goal. Over the past decade, K-12 stakeholders have been collaborating to define the underlying technical and architectural standards necessary for such plug-and-play interoperability. These initiatives are producing useful and promising results. Although the process is far from complete, the foundation for interoperability exists today.

There are many different, overlapping categories of interoperability, each with its own challenges and evolving standards. File sharing – involving common file formats such as HTML and XML, PDF, and Open Document Format – is a simple form of interoperability that has matured to such a degree that many of us take for granted the ability to use our choice of tools to read, and even edit, files that were created in a totally separate application. Another important aspect of interoperability that could form the basis of an entirely separate publication is the set of standards that relate to accessibility.

For the purposes of this monograph, however, we will focus on the following specific areas of interoperability: content interoperability; data connectivity; data integration; identity management; and portal interoperability.

**Content interoperability standards**

21st century educational environments depend on a high level of interaction among sources of academic content, application software, and the networked computing infrastructure of an educational enterprise. Thus, it is becoming increasingly important for content to be developed in a way that allows it to be integrated into multiple enterprise service environments that include both new and legacy content and services. However, many digital course materials and the software for using them still function as standalone systems. This situation results in redundant content creation and solutions that are too expensive; it limits the use of the content that is created; it expands the range of technical difficulties involved in integration,

**CURRENT CONTENT INTEROPERABILITY STANDARDS**

**COMMON CARTRIDGE:** Common Cartridge is the IMS Global Learning Consortium’s format for content in “distributed learning” environments, both on- and off-line. IMS was started in 1997 as an initiative of EDUCAUSE. The initial focus was on higher education, but the scope has broadened to include K-12, as well as corporate and government e-learning initiatives. Common Cartridge uses IMS’s most widely adopted specifications to define a common format that allows course materials from any provider – as well as content developed in-house – to be mixed and matched. The format is flexible; a Cartridge may be an assessment filled with test items, supplementary digital content provided with a textbook, an online course, a lesson plan, or a topical learning object complete with assessments, and feedback. Common Cartridge has emerged as the primary standard for digital content in K-20 education environments. It is actively maintained and supported, and includes integrated companion standards. Vendor implementations are increasing. In conjunction with the Common Cartridge, the IMS Global Consortium has developed two standards that are relevant to both content and data interoperability: LTI (Learning Tools Interoperability), provides a single framework for integrating rich learning applications with platforms such as learning management systems and portals; and LIS (Learning Information Systems), defines how systems manage the exchange of information that describes people, groups, memberships, courses and outcomes within the context of learning.

For more information: imsglobal.org/commoncartridge.html
imsglobal.org/digitallearningservices.html

**SCORM CAM:** SCORM (Sharable Content Object Reference Model) was developed by the Advanced Distributed Learning (ADL) Initiative. The ADL, which was established in 1997 by the U.S. Department of Defense, has worked with multi-national groups from industry, academia, and government to define specifications and standards for education and training and to develop tools and content to support the use of SCORM. SCORM content is used for informal learning such as educational reference, for on-the-job training, and for performance support. The SCORM Content Aggregation Model (CAM) defines how to aggregate, describe and sequence learning objects. Compliance with the SCORM CAM is required in some government agency RFPs or for contracts for training applications in the U.S. and internationally. SCORM was last released in 2006 and updated in 2009. Conversion tools are available to make SCORM-compliant content (typically referred to as SCORM “packages”) compatible with the IMS Common Cartridge.

For more information: adlnet.gov/Technologies/scorm/default.aspx
The Open Database ActiveX Data Objects Online Linking and XML (eXtensible Markup Corporate members, educational service agencies and institutes of higher education may distribute to internal staff. No one may repost this publication to public Web sites, external list serves, blogs, wikis or other publicly accessible forums. Permission to distribute beyond these parameters must be granted explicitly by CoSN and copyright ownership must be noted. To join or learn more about CoSN, visit www.cosn.org.

STANDARD DATA CONNECTORS IMPORTANT TO INTEROPERABILITY

**ODBC:** The Open Database Connectivity (ODBC) interface by Microsoft allows applications to access data using the popular Structured Query Language (SQL) as a standard. ODBC permits maximum interoperability, which means a single application can access different database management systems. Application end users can then add ODBC database drivers to link the application to their choice of database management system.

*For more information:*  
msdn.microsoft.com  
simba.com/odbc.htm

**JDBC:** Java Database Connectivity (JDBC) is an API specification originally developed by Sun Microsystems for connecting applications written in Java to data in popular databases. The JDBC API lets users encode access request statements in SQL that are then passed to the application that manages the database. It returns the results through a similar interface. JDBC is very similar to ODBC, and with a small "bridge" program, one can use the JDBC interface to access databases through the ODBC interface – for example, writing an application designed to access many popular database products on a number of operating system platforms.

*For more information:*  
download.oracle.com/javase/tutorial/jdbc/basics

**ADO.NET:** ActiveX Data Objects (ADO) is the data access model provided for Visual Basic users to write applications for the Microsoft Windows platform. ADO is also used by VBScript, which is a specialized language that is used primarily to program functionality for web pages. The ADO.NET (ActiveX Data Objects for .NET) data standard by Microsoft provides a uniform method to access data from a number of data sources within Microsoft’s .NET Internet framework. It encapsulates ways to connect to a database and access data, be it relational, XML, or application specific, and it enables application developers to retrieve the results.

*For more information:*  

**OLE DB:** Online Linking and Embedding Database (OLE DB) is Microsoft’s strategic low-level API for embedding objects from different data sources. The original goal was to offer an object-oriented alternative to standards such as ODBC, but it is mostly used today for object embedding and co-exists with such other standards as ODBC and JDBC.

*For more information:*  

**XMLA:** XML (eXtensible Markup Language) is a widely-supported specification, produced by the Worldwide Web Consortium for encoding documents as a textual data format with strong support for the representation of data structures and programming. XML-based formats have become the default for most office-productivity tools, including Microsoft Office, OpenOffice.org, and Apple’s iWork. XMLA (XML for Analysis) is an extension of XML that employs a set of XML message interfaces that are used to define data access interaction between a client application and an analytical data provider working over the Internet. It allows client applications to talk to multi-dimensional or OLAP data sources. XMLA is designed for thin client architecture, moving analytical applications away from traditional client/server roots towards flexible web-based architecture. The result is faster response times and less intensive demand on resources. What differentiates XMLA from previous attempts at a standard is that it has already gained broad support, with companies including Oracle/Hyperion, Microsoft, SAP, and SAS supporting it.

*For more information:*  
news.xmlforanalysis.com
Data Connectivity

The main objective of data connectivity standards is to support the transfer of data between a variety of platforms using a standard set of commands in an efficient and cost-effective way. Data connectivity is essential for such mission-critical applications as enterprise resource planning (ERP), student information systems (SIS), and data warehouses, which have low tolerance for delays or errors related to accessing, processing, and storing data. Unreliable data connectivity design can lead to poor performance, availability, and scalability, and to data integrity issues that have a direct impact on cost and risk for the district.

There are several connectivity standards in the market today for accessing the most popular database platforms (see page 3). Making a pro-active, conscious decision to use enterprise products that support a single data connectivity standard can help greatly with production performance, reliability, and scalability. When this is not possible, it is necessary to find data solutions that address the connectivity challenges offered by multiple standards.

Vendors of databases and other data-oriented solutions typically create drivers that are designed to meet the basic requirements of the major standards and provide a minimal level of data connectivity for their products. Provided at no extra cost, these default drivers might appear to be cost effective but they can fall short of the performance requirements for critical systems and necessitate the purchase of additional, expensive drivers that increase overall support and maintenance costs. In addition, some database providers have chosen to add proprietary extensions to data connectivity standards, improving performance for that particular product but, at the same time, eliminating the benefits of a standardized application program interface (API) and making it difficult for customers to switch to another vendor’s database engine. This is often referred to as a “lock-in.”

Third-party database connectivity products offer an alternative for critical system deployments. Such products serve a specialized purpose — facilitating data connectivity between all the components of a data system — and typically support required features without forcing lock-in to a specific database or version. Within the category of third-party solutions, developers and IT managers should look closely at the following factors before selecting a vendor:

- **Product comprehensiveness**: Product breadth, including being current with specifications and providing unmatched coverage across APIs (JDBC, ODBC, ADO.NET), databases (Oracle, Microsoft SQL Server, DB2, Sybase, Informix, and more) and operating systems (Windows, UNIX, Linux, iSeries, z/OS).
- **Production-proven**: A record of successful use in a variety of environments as well as quality-proven through specification certification and a large customer base.
- **Technical support**: Multi-channel support via phone, fax, email, Web.
- **Technical leadership**: Industry-trusted specification leader for JDBC, ODBC, ANSI SQL, and XQuery.
- **Corporate focus and strength**: 100% focused on database connectivity.

Data Integration

In recent years, IT environments have become more complex and more heterogeneous due to diverse customer needs and rapid innovation in the IT industry. Integrating data across the enterprise has become critical for increasing productivity, improving business efficiencies, and reducing costs.

Data integration begins with data connectivity (described earlier), but goes beyond it to include data translation, standard data output format, and other transformation services to make the data usable by each individual application. It involves combining data residing in different sources and providing users with a unified view of these data. This process becomes
CURRENT DATA INTEGRATION STANDARDS

SCHOOL INTEROPERABILITY FRAMEWORK (SIF): SIF is an open standard for K-12 data exchange that is designed to enable diverse applications such as library, student information, and transportation systems to interact and share data. SIF is composed of the SIF-Connect Server and the Universal Agent Suite tools. The goal of SIF is to ensure that all SIF-compliant applications achieve data interoperability, regardless of what software and hardware was used in their development. Recent developments in SIF include vertical reporting (the reporting of high stake test results from schools up through the hierarchy of district and state systems to the federal government) and the introduction of objects related to e-learning content. The SIF association has just released the new SIF Web Services reference infrastructure. It converts the entire SIF Zone into a web service and enables developers to utilize industry standard toolkits to create web service applications that can access and update all SIF-conformant educational data utilizing the widely available Simple Object Access Protocol (SOAP) and Web Services Descriptive Language (WSDL) technologies. SIF enhances data interoperability by the use of the XML standard, which is already popular in K-12. In recent years many companies in the K-12 market have embraced the data integration standards contained in SIF and districts frequently require their vendors to comply with SIF. Additionally, a number of vendors in K-12 have developed SIF agents that allow their products to interoperate easily with products from other vendors.

For more information: sifinfo.org

ENTERPRISE SERVICE BUS (ESB): ESB is a software architecture that provides services for event-driven complex architectures using a standards-based messaging engine (the “bus”). While SIF is more focused on data integration, in general, ESB focuses more specifically on the integration of web applications. Developers typically implement an ESB using technologies found in a category of middleware infrastructure products, usually based on recognized standards. An ESB provides an abstraction layer on top of an enterprise messaging system, which allows integration architects to exploit the value of messaging without writing code. In an enterprise architecture making use of an ESB, an application will communicate via the bus, where the ESB acts as a message broker between applications and enables communication among them. Such an approach has the primary advantage of reducing the number of point-to-point connections required to allow applications to communicate.

For more information: en.wikipedia.org/wiki/Enterprise_service_bus

CoSN COMPENDIUM 2011

significant in a variety of situations in education. One situation involves data warehousing. The warehouse system extracts, transforms, and loads data from several sources into a single schema that can be queried. As a result of data integration, disparate data silos can be combined logically into a single and uniform data source in the data warehouse without having to migrate the physical data.

Another situation involves integrating applications – for example, an ERP system that combines finance, human resources and student information from different sources – in order to simplify and automate business processes to the greatest extent possible, while at the same time avoiding having to make sweeping changes to the existing applications or data structures. One large challenge of data integration is the fact that these data structures often reside on different platforms that need to be linked together using different database solutions and computer languages.

Currently, there are many different ideas regarding what constitutes a good standard for data integration although some commonly accepted components include:

1. Either an architecture that permits “self-assembly” of network members or a broker to centrally manage security, access, and communication. The SIF Zone Integration Server (ZIS) and the Enterprise Service Bus (ESB) are examples of a service based on the broker approach.

2. An independent data model based on a data structure standard such as XML.

3. A connector that can speak natively with the centralized broker or directly to member nodes where no central broker is used.

4. A system model that defines the data flow and rules of engagement for interfacing with it in a standardized way.

Data integration challenges appear with increasing frequency.
as the volume and the need to share existing data explodes. This area – frequently referred to in management circles as “Enterprise Information Integration” (EII) – has become the focus of extensive work, and numerous open questions and problems remain unsolved.

A suggestion to consider when undertaking an EII project is to start with easier problems and get “wins” early in the project. It is important to design a solution that can grow to meet your needs, but if you have to restructure your entire data model to participate, it’s less likely you will be able to demonstrate success soon enough to maintain support for the project over its lifecycle.

Identity Management Standards
Identity management involves the business processes and supporting infrastructure needed for the creation, maintenance, and use of digital identities. The central questions an Identity Management System (IDM) seeks to answer are:

Who are you? What are you allowed to do? How will the resources be managed in order to provide you the required access?

The first question is referred to as authentication. The authentication process involves identifying who the user is through a user ID, password, smart card, fingerprint, or some other means.

**IDENTITY MANAGEMENT STANDARDS**

**SAML:** The Security Assertion Markup Language (SAML), was developed by the OASIS Security Services Technical Committee, a global consortium involved in the development, convergence and adoption of e-business and web service standards. Its primary goal is to address the challenge of web service standards. Its primary goal is to address the challenge of web service standards. SAML uses an XML-based framework for communicating user authentication, entitlement, and attribute information. It enables single sign-on by allowing users to authenticate at an “identity provider” and then access “service providers” without additional authentication. Identity federation (linking of multiple identities) with SAML allows for a better-customized user experience at each service while promoting privacy. For more information: oasis-open.org/committees/security/

**SHIBBOLETH:** A project of the Internet2 Middleware Initiative, the Shibboleth System is a standards-based, open source software package for web SSO across or within organizational boundaries. It allows sites to make informed authorization decisions for individual access of protected online resources. Shibboleth uses the SAML federated identity standards to provide a federated single sign-on and attribute exchange framework. Shibboleth also provides extended privacy functionality, allowing the browser user and their home site to control the attributes released to each application. With the Shibboleth System, a user authenticates with his or her organizational credentials. The organization (or identity provider) then passes the minimal identity information necessary to the service manager to enable an authorization decision. Shibboleth is developed in an open and participatory environment, is freely available, and is released under the Apache Software License. For more information: shibboleth.internet2.edu/

**OPEN ID:** OpenID authentication is a decentralized Single Sign-On service managed by the OpenID Foundation. It is simple, free and provides the verification of a user’s identity from an identity provider to a service provider. OpenID is used by several large providers including AOL, Google, MySpace, PayPal, Yahoo! and VeriSign. It is a protocol that is easy to use and implement for web account access. Its decentralized and portable characteristics make it very attractive to users. For more information: openid.net/foundation

**LDAP:** The Lightweight Directory Access Protocol (LDAP) is an application protocol for querying and modifying data from directory services implemented in Internet Protocol (IP) networks. LDAP provides for a complex level of access control instances (ACIs) that make it easy to securely delegate read and modification authority. The ACIs can control access depending on who is asking for the data, what data is being asked for, where the data is stored, and so on. This access is controlled on the server side, rather than through client software, making it more secure. The LDAP protocol is an open protocol that is both cross-platform and standards-based, so applications need not worry about the type of server hosting the directory. It is supported by Microsoft, IBM, and other major vendors. There is also an open source implementation (OpenLDAP). For more information: tech-faq.com/ldap-lightweight-directory-access-protocol.html

© CoSN 2011. The full-text version of this paper is a CoSN members-only publication. Institutional members may reprint this publication to use within their schools or district. Corporate members, educational service agencies and institutes of higher education may distribute to internal staff. No one may repost this publication to public Web sites, external list serves, blogs, wikis or other publicly accessible forums. Permission to distribute beyond these parameters must be granted explicitly by CoSN and copyright ownership must be noted. To join or learn more about CoSN, visit www.cosn.org.
or combination. The second important aspect of identity management is **authorization** – specifying access rights to resources. During the authorization process, the system uses a set of access control rules to decide whether requests shall be granted or rejected. In the K-12 world, this is generally accomplished by feeding user demographic data from human resources and/or student information systems to the identity management system. Additional information is derived from the user's demographics to determine authorization to various systems. For example, if the user is a classroom teacher, the system knows to automatically grant him or her access to the grading system.

When one starts to list all of the internal systems that require user name, password, rights, and role information, the list can be quite long. Student information systems, grading systems, special education databases, and file sharing tools are just a few examples. A variety of external systems in use by schools also benefit from identity management. This multitude of online systems requiring identifying information creates evolving identity management challenges and has led to a new approach known as “federated identity management.” Communications protocols that support federated identity management allow users to employ the same user ID and password to sign on to multiple enterprise networks. This is also known as single-sign-on or SSO.

The third aspect of identity management relates to the **administration** of resources available for authenticated users to perform authorized work. The administration of a central identity management repository across systems to create a single user account within a directory services system such as Microsoft’s Active Directory or Novell’s eDirectory can be further enhanced using open standards protocols such as LDAP. Generally speaking, authentication and authorization processes will flow outward from an identity repository, so it is critical for this system to be well maintained, including effective processes for keeping it aligned with HR/personnel and business process changes.

In a school setting, one example of identity management might be a school district and local community college agreeing to federate identities so that high school students can log on to the wireless system at the community college in order to access online resources. Granting access would require that the community college trust the quality of the K-12 district’s identity system, and agree that the district policies for ensuring authentication are acceptable to them for access to the wireless system. In this scenario the risk is reasonably low, so the trust required would likely be low as well. On the other hand, if a school wanted to have its students log on to take online tests or participate in college-level classes the risk of poor authentication would clearly be much higher.

---

**CURRENT PORTAL INTEROPERABILITY STANDARDS**

**JSR 168 and 286:** JSR (Java specification request) 168 and the newer JSR 286 address the areas of content aggregation, personalization, presentation, and security. It defines the functionality of a portlet container and the standard interface through which it interacts with user-specific portlet code. It also provides a URL-rewriting mechanism for creating user interface within a portlet container and defines ways of effectively handling portlet security and personalization characteristics. For more information: jcp.org/

**WSRP:** Through the efforts of the Organization for the Advancement of Structured Information Standards (OASIS), WSRP (web services for remote portals) defines a standardized interface between a portal and portlet service that allows the plug and play of visual, user-facing web services with portals. It facilitates interoperability between a WSRP-enabled container and any WSRP-compliant portal, allowing Java portlets to plug into WSRP-enabled portals. For more information: oasis-open.org/committees/wsrp
IDENTITY MANAGEMENT CASE STUDIES

San Diego Unified School District, California

The San Diego Unified School District (SDUSD) includes more than 15,000 employees and 120,000 students located in 225 schools. For a district of this size, the evolution from disparate servers, networks, and applications to an integrated network directory has been long and difficult. Today, however, SDUSD successfully operates a complex and robust network operating system and directory based on Microsoft’s Active Directory (AD).

The AD logical design consists of a “single forest single domain model” that allows groups to be viewed at different levels. Within this, the identity structure reflects the organization of the district. Each school, department, and office has a separate Organizational Unit (OU) for its users, groups, and computers. Thus, if one knows the work location of a particular user, it is possible to quickly locate a user’s account object within the directory. Additionally, departmental and school shared file folders and other resources are easily managed with the proper Access Control Lists (ACLs) based on AD Security Group membership, which is tied to the office location of the user.

Staff accounts, residing in a consolidated database, are provisioned automatically and managed through a middleware utility that reads changes to employee accounts in the district’s HR system and adds, changes, or disables user accounts based on these changes. Student accounts are provisioned similarly through another middleware utility that creates the password for each student it adds and then writes a human readable copy of that password back to a table, giving the classroom teacher the ability to run a report of their students with passwords listed and distribute them to the students.

Austin Independent School District, Texas

There are three methods for creating user identities in Austin ISD. As users are added to these systems, their demographic information flows to a consolidated database. In the database, roles are provisioned via SQL scripts that identify specific demographic attributes such as location, position or grade level to determine the roles that will be assigned to the user. These roles will become attributes and group memberships in a LDAP- and DS-compatible directory listing to determine access to applications.

This entire on-boarding process occurs three times a day, with most students and employees having their identities built and fully provisioned before they arrive at their campus. As the user goes through life at Austin ISD various roles are automatically reassigned. For example, when a student or teacher moves from one campus to another, the system automatically provisions the new access roles and deletes those roles that no longer apply. When a user leaves the system, the identity is disabled from system access but the data and demographic data may stay in the system for a few months to a few years depending on the expiration rules for the systems involved.

As the internal systems take advantage of the LDAP connections for authorization and authentication, the need to have multiple user IDs and passwords, is eliminated. This allows for an improved user experience, and more centralized controls over the entire identity life cycle.

Portal Interoperability

In the era of cloud computing, portals – ranging from public gateways such as Sharepoint, Google, and Yahoo to various education-specific portals – have become increasingly important and commonplace. Pluggable user interface components known as portlets help make such portals flexible and dynamic. In order for a portal to be able to communicate and pull in data and applications from other Web-based sources, the different online resources need to have a uniform standard that allows them to work together. This is particularly important to districts in the era of cloud computing when integrating systems through the cloud is vital to provide a flexible user interface to relevant information systems. Without standards-compliant portlets, a district’s online presence remains a static Web site rather than a true portal that integrates a wide array of tools and resources.

In recent years several standards have been introduced to address portal interoperability challenges. These standards provide essential compatibility features that allow developers to build portlets once and expect a seamless interoperability with any compliant portal. This allows cost and features, rather than
compatibility, to be the driving factor in decision making and makes it easy for organizations to receive direct feeds from external web sites by taking advantage of the standard portlet interface.

Additionally, many public and educational gateways provide “API” access to their systems, which can offer an alternative technique to portlets. Google maps, Amazon product catalogs and Twitter data are all examples of API-enabled services that allow a web site to have powerful dynamic content via API access.

**Looking Ahead**

There is no one-size-fits-all approach to realizing the benefits of standardization. The development of robust, reliable industry standards is a slow process and involves costs as well as benefits. How do you know when a set of interoperability standards is worth adopting?

To some degree your decision should be based on a realistic assessment of the maturity and empirical support for any standard. The more mature the approach or standard, the more likely it is to have support in the form of a community of practitioners, available documentation, practical examples,
training, and a pool of skilled staff members. On the other hand, a newer standard may be supported by enthusiastic pioneers and offer professional development and collaboration opportunities that compensate for the lack of industry maturity.

Even more important is determining how well the standard meets your needs. Will adopting the standard enable a critical user activity or high priority enterprise capability? Will it lower your costs, shorten development time or facilitate the maintenance and evolution of crucial systems? If the need is there, then carefully researching the different options in order to invest in products and approaches that support your chosen standard will be well worth your time.

With the rising importance of cloud computing, online learning, portals, modularity, data warehousing and performance management, interoperability standards have become more crucial than ever before. As the IT world shifts from a product-oriented to a service-oriented environment and schools struggle to make ends meet, it is essential for K-12 technology leaders to learn how to maximize the benefits of existing enterprise systems while adding new solutions that are cost-effective and scalable. None of this is possible without interoperability.