



Primer on K-20 Education Interoperability Standards

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SIIA Primer on K-20 Education Interoperability Standards

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About SIIA

The Software & Information Industry Association (SIIA) is the principal trade association for the software and digital content industry. SIIA provides global services in government relations, business development, corporate education and intellectual property protection to more than 800 leading software and information companies.

SIIA's Education Division serves and represents over 150 member companies that provide software, digital content, and other technologies that address educational needs. The Division shapes and supports the industry by providing leadership, advocacy, business development opportunities, and critical market information.

SIIA Education Division provides a neutral business forum for its members to understand business models, technological advancements, market trends, and best practices. With the leadership of the Division Board and collaborative efforts with educators and other stakeholders, the Division undertakes initiatives to enhance the use of educational technology and the success of SIIA members.

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About This Primer

This Primer on K-20 Education Interoperability Standards is just one component of SIIA's ongoing efforts to help inform on technical issues that are important to the success of educational technologies. Interoperability standards¹ facilitate the exchange of information between educational systems and support the integration of content, data, and components from different suppliers. Adopting and using such standards is improving educational outcomes and changing the business of education for both vendors and consumers. This Primer provides a framework for understanding interoperability standards that impact educational data, digital content, and software applications. It is not a "how to" guide for choosing or using standards, a technical manual, or a comprehensive, detailed survey of all available standards.

The Primer takes a pragmatic point of view regarding the challenges and benefits of interoperability. This discussion is intended for both vendors and consumers (i.e., for developers of educational software, digital content, online services, and related technologies on the one hand, and for education leaders who specify, acquire, and use these technologies in agencies and institutions on the other). The Primer assumes only a general familiarity with interoperability and with its potential return on investment. It is not intended for standards experts or for direct end-users of educational technology (i.e., faculty, students, and staff).

Making practical decisions about when to implement, or require compliance with, interoperability standards requires a broad understanding of the relative maturity of standards, the trade-offs involved with using them, and their short-term and long-term impact. The Primer seeks to give SIIA members the context they need to actively promote interoperability as a business goal and to use interoperability to create opportunity and improve operational efficiency. The Primer also seeks to provide education leaders with a basic understanding necessary for requiring interoperability and for encouraging further standards development. Appendices describe organizations and initiatives involved with standards and their promotion and define relevant concepts and terms.

Acknowledgements

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SIIA would especially like to thank those who provided peer review of the draft:

¹ This Primer uses the terms "standard" and "standards organization" or "initiative" in their everyday, generic senses without differentiating between what experts refer to as standards or specifications. Unless otherwise noted, this Primer does not use the terms standards to refer to learning standards for learning outcomes.

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This Primer updates a version developed in 2008 by Educational Systemics, a service organization offering experience in education, technology, and business planning for the K-12 market. Educational Systemics works closely with K-12 businesses to conceptualize, design, develop, position, and identify sales opportunities for products that address the education community. Visit www.edusystemics.com.

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Preface

A Message from the SIIA Technical & Development Committee

We are pleased to share this SIIA Primer to help inform the K-20 community on, and advocate for, this important issue of education interoperability standards. Further adoption now, and continued development into the future, of technical interoperability standards are necessary to maximize the impact of educational technologies. Interoperability enables innovation and improves products and services for consumers and vendors alike. Interoperability standards enhance our ability to identify and access digital content from disparate sources, to assess performance and inform administrative decisions, and to meet the needs of individual learners. Vendors can deliver digital content and educational software more efficiently to a variety of sectors within the market, and educational institutions can blend systems and content from a variety of sources. Educators can better differentiate instruction and students can better personalize their learning.

This document is written as a primer for educational stakeholders to provide context for their understanding and productive participation in the development and adoption of interoperability standards. This primer arose from the awareness that there is much confusion about the definition and goals of interoperability, as well as about the numerous standards. It also arose from the view that the full promise of technology in education is not easily possible without interoperability implementation. And finally, this primer arose from a view that, while the broad access to data and integration of disparate resources that interoperability makes possible do challenge existing business models, the ability of the software and digital content industries to meet education needs depends on their genuine adoption of interoperability standards.

Adopting interoperability standards will yield obvious value to both vendors and consumers. Yet uncertainty about when to implement standards inhibits both from proactively exploiting the standards that exist. Part of such uncertainty is unavoidable: technology-based education is evolving rapidly, and the standards that support its development and practice are changing to track this evolution. The level of detail and fineness of distinctions inherent in technical discussions inevitably gives rise to confusion in a general audience. This Primer attempts to address such perceived impediments to the use of interoperability standards by providing a general framework and a simplifying overview of currently usable standards.

Failing to further the adoption and evolution of interoperability standards will stall continued innovation, limit variety and choice, and prevent the simplification of technology that education so desperately seeks. “Wait and see” is a risky strategy for all parties. Delaying adoption will undermine the investments that pioneering vendors have made and increase the cost of eventual adoption to consumers.

SIIA members and others in the industry recognize that interoperability will enable technology to truly deliver its power and vision to transform instruction, personalize

learning, and enable data-driven decision. Advocating interoperability will drive educational improvement and will increase demand for technology, resulting in more opportunities for all.

To realize the full value of interoperability in education, we urge all stakeholders to promptly develop, adopt, and implement mature interoperability standards and leverage the benefits of standards compliance. For those who have made investments to help create or adopt interoperability standards, pursue the competitive and educational advantages that they provide. For those educational decision makers, who are the ultimate beneficiaries of interoperability, prioritize compliance in procurement decisions and measure the impact of interoperability on operations and outcomes.

We call on both vendors and consumers who have waited to adopt interoperability standards to move forward now to ensure that educational technology continues to mature, grow, and better serve the needs of educators, students, and the public at large.

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SIIA Primer on K-20 Education Interoperability Standards

Introduction

Interoperability is an Educational Imperative

Educational systems are accelerating their transition to the digital age – moving from print to digital content, blending virtual learning with the traditional classroom, and leveraging data in sophisticated ways to support instructional and policy decisions. The adoption of technology is having a positive impact. But growing sophistication in the use of technology is exposing gaps in processes, which are slowing pedagogical and technical innovation and limiting gains in efficiency and effectiveness.

Students, educators, and administrators have come to expect seamless integration of disparate content resources, data from various sources, multiple software applications, and enterprise IT systems. They seek to blend the best of breed applications and resources, leverage data horizontally and vertically, and employ adaptive software engines to personalize learning by aligning dynamic results with academic content and instruction. Increasingly they do so anytime and everywhere using any platform and device.

Underlying each facet of this vision is the tacit requirement for interoperability. The usability of isolated data, content, and applications is rapidly diminishing. Educational agencies and institutions are seeking to strategically leverage their assets across a number of systems. Interoperability is a necessary capability for the systems that are emerging.

The case for interoperability is increasingly compelling. Perfect interoperability would make it possible to use any data, any digital content, and any software application on any system. Users could easily and continuously access, create, and share content or data from multiple sources on any device, using any platform to perform a variety of tasks. Developers could quickly and cheaply mix and match digital resources and software applications and readily integrate them with existing administrative systems and software.

Real world interoperability will always fall short of this ideal. It requires a practical compromise between program requirements and product capabilities; between costs and benefits to vendor and consumer; and between access to data or trade practices and protecting personal privacy or competitive advantage. In the real world, both too much and too little interoperability can prevent vendors from providing, and consumers from acquiring, optimal solutions. But just enough interoperability leads to better solutions and better bargains.

Seek simplicity, and distrust it.
Alfred North Whitehead (1861 - 1947)

As a consequence, interoperability is both desirable and necessary, but interoperability depends on trade-offs. Therefore, interoperability is a system-level benefit.

Interoperability Is Both Desirable And Necessary.

Interoperability is desirable because it makes acquiring, maintaining and evolving the infrastructure that supports education and administration more affordable, flexible, and sustainable. Interoperability is necessary because, without it, combining the many sources of content or data and variety of software applications that must work together to support instruction, assessment, or various management and administrative functions would be impractical, if not impossible.

But Interoperability Depends On Trade-Offs.

Realizing the benefit of interoperability across an entire line of business or throughout an institution's IT infrastructure may complicate producing or acquiring individual applications. Moreover, non-technical considerations such as policies, timing, or legacy systems constrain technical design choices. As a consequence, justifying investment in interoperability involves balancing short term or local convenience and long term, global goals in order to make an installed system more powerful and more versatile.

Therefore, Interoperability Is A System-Level Benefit.

The general benefits of interoperability – supporting consumer choice, enabling efficient development and acquisition, ensuring the evolution of an IT infrastructure, and unlocking value-added innovation – all require that the individual components that make up an educational system communicate readily with one another and be individually replaceable. This kind of many-to-many, system-level compatibility makes the components themselves more efficient and more effective in the context of their use.

The benefits from interoperability derive from its overall effect on entire IT infrastructures and complete educational processes, not simply from the individual components or individual steps in a business process being interoperable. It is particular educational transactions such as instruction or assessment and the IT environments of specific institutions that determine which infrastructure and components are appropriate. A collection of flexible individual standards that can be combined and configured for use in a variety of contexts is more effective in this context than one comprehensive standard.

Everything should be made as simple as possible, but not one bit simpler.
Albert Einstein (1879 - 1955), (attributed)

A Brief History of Education Interoperability

Prior to the 1990's, interoperability was not a technical requirement for either vendors or consumers. What digital content and educational technology was being developed was largely restricted to local or special purpose computing environments and delivered using

stand-alone systems. The hypothetical benefits of making digital content, administrative data, or educational software interoperable simply did not justify the real cost of doing so. Vendors produced proprietary designs for stand-alone systems that solved the particular needs of their customers. Version-to-version compatibility or easy integration with components or systems from other vendors had low priority. Likewise, educational researchers and consumers acquired or created content and technology that met their local teaching and administrative requirements but did not necessarily support re-use, data sharing, or collaboration, or call attention to the benefits of interoperability.

With the development of the World Wide Web and, to some extent, with the increasing size and visibility of investments in digital content and educational IT, the need for interoperability became apparent. In the mid-1990's, the desire for greater modularity in system architecture and for more portable and reusable educational technology led to the formation of several standards organizations. The increasing and persistent focus on reducing cost has added to this drive towards interoperability.

The organizations that were formed successfully developed standards for the major pieces of the interoperability puzzle discussed below. The progress they made now allows vendors' and consumers' attention to shift toward applying technical standards to integrate educational and enterprise components from a variety of sources.

Education and Mainstream Interoperability

Today's technical and human infrastructure for delivering education is becoming less unique to education. "Educational" technology is more and more the application in education of mainstream technology that is used in consumer, enterprise, and other marketplaces. Moreover, educational experiences have analogues in everyday consumer experiences that determine expectations for technology in education. These marketplace solutions certainly can be imitated and may even be exploited directly to lower costs and increase capability in education. For example, the personalization, adaptive interaction, single sign-on, data mining, and data sharing that underlie the Amazon marketplace are in some ways more advanced than similar capabilities in school districts or higher education systems. The imperative for educational interoperability is growing as these other sectors leverage interoperability, and as the education sector learns to exploit the technologies that result.

Primary Areas of Educational Interoperability

Most educational interactions rely on interoperability among a variety of content repositories, data management systems, and software applications. Three general kinds of activity are involved in such interactions:

- Moving the digital content required for learning and assessment to enable its integrated use in an array of platforms;

- Exchanging academic and administrative data among databases and software applications as required to assess performance and support administrative reporting; and
- Integrating educational and administrative applications with each other and with local and system-wide enterprise software systems to support complete scenarios of interaction.

To support such activity, the components that make up educational systems must observe standards for:

- Describing digital content, and school and student data;
- Programming interfaces for applications; and
- Communicating among applications.

As an example, consider a scenario of instruction in which a student logs into a learning management system (LMS), is presented with digital content from a repository, and makes responses that are recorded by the LMS and exchanged with a student information system. Moving digital content from a repository to an LMS requires that the repository and the LMS share a common description of the content (i.e., a content packaging standard) and have compatible program interfaces (i.e., an application programming interface standard). Identifying the student and recording results in the student information system requires that the LMS and the Student Information System (SIS) share formats for describing student data (i.e., a data standard) and also have compatible programming interfaces. (See Figure 1)

Implementing these technical standards allows a compliant content repository, SIS, or LMS to be integrated with another compliant system. Even this simple example illustrates the power of interoperability standards to facilitate the use of content and exchange of data across applications, to increase consumer choice, and to reduce the developer effort required to assemble data/content or change components. The more applications that use the standards, the greater will be their value.²

As Figure 1 illustrates, a complete standard must provide a formal description of the structure of some collection of content or data and specific instructions for how that content or data is to be transported between the components of a network system and processed within them. To do this the standard either incorporates or refers to definitions or rules that address the following:

- Meta-data: Data about data that identifies and describes the elements of an item of content or set of data in a standard manner so that they can be recognized and used across applications that subscribe to the standard in question;

² In a more realistic example, the LMS and other educational software (such as assessment and personalization systems) would be used to present content taken from several content repositories and would record data from a variety of teacher and student interactions that would then be exchanged among several pedagogical and administrative databases.

- Transport protocols: Common procedures for establishing connections over networks between systems/applications to enable transferring of content or data, or for executing functions by different components of a networked system; and
- Interface rules: Standard Application Programming Interfaces (APIs) with instructions for using the common functions of an application, such as accepting input, executing a routine, providing data, etc.

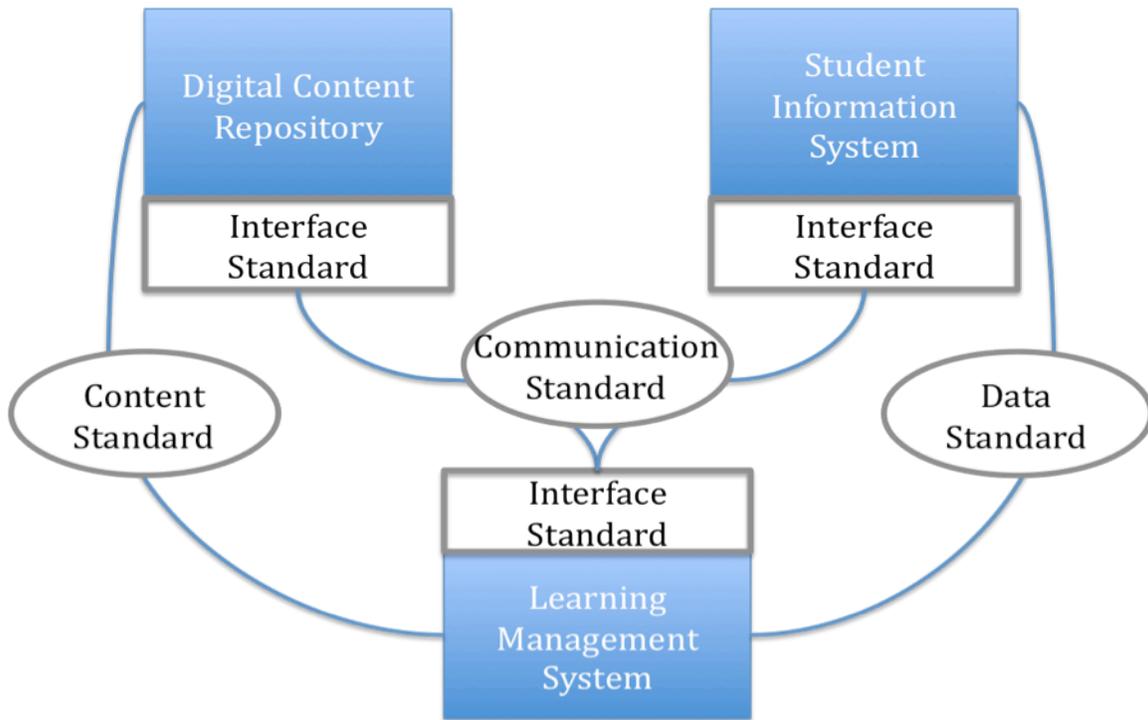


Figure 1. A Simplified Educational Infrastructure

Specifying metadata, protocols, and interfaces is only the first and, in some respects, the easiest step in creating a useful standard. A successful standard is an ecosystem. To be useful, a standard must also be implemented by vendors and its compliance required by consumers. A stable organization with active communities of vendors and consumers must be created and sustained, and compliance or certification tests must be developed and maintained to support its use. Resources such as best practice guides and case libraries must be made available to help software vendors create, and institutions and practitioners acquire, compliant products and services.

Interoperability in Educational Domains

Following is a framework for considering selected standards from the IMS Global Learning Consortium (IMS), the SIF Association (SIF), the Postsecondary Electronic Standards Council (PESC), and the Advanced Distributed Learning Initiative (ADL), among others. These standards meet the ecosystem criteria described above and address

the major functions involved in supporting educational activity that were identified earlier, namely:

- Moving content;
- Exchanging data; and
- Integrating software applications.

Many additional standards are available from these and other organizations, and new initiatives to develop or promote standardization have started recently.³ The full impact, if any, of other existing standards and new initiatives will be felt once development and implementation are complete, and the infrastructure necessary to support everyday use of such standards by a community of practice has been established. Therefore, discussion of them in this version of the Primer is limited to basic information provided in Appendix 1.

Moving Content

Authors, publishers, open source groups, students, and faculty produce a great variety of digital content. This content ranges from eBooks to courseware, video files to simulations, and learning objects to banks of test questions. It is available in various file formats from the cloud, from content repositories, and from a variety of public and private sources. Educators and students today mix and match such sources of digital content. They want to:

- Access all sources of content from a single starting point;
- Acquire and integrate content to build combinations of learning materials that align to their lesson plans, meet standard learning objectives, and address individual student needs; and
- Distribute content to students via any of several channels such as an interactive whiteboard, an LMS, a simulation engine, or a mobile app.

Mixing and matching units of content from multiple sources can raise challenges to the educational and administrative integrity of the content, to the fair use of intellectual property, as well as to curriculum design and the choice of instructional paradigm. No single resolution exists or is likely to emerge for these concerns. Consequently, content standards must support a range of working solutions to pedagogical, business, and policy problems.

³ These new efforts include the Shared Learning Infrastructure, Ed-Fi, the Learning Registry Initiative, Schema.org, and the Learning Resource Metadata Initiative.

Content Standards

Education specific content standards include IMS Common Cartridge, IEEE Learning Object Metadata (LOM), ADL Sharable Courseware Object Reference Model (SCORM), and Dublin Core Metadata.⁴

IMS Common Cartridge is the primary eXtensible Markup Language (XML) standard for describing a package of digital content. The standard package that Common Cartridge provides allows content to be moved to a digital library or into and among applications such as LMSs or assessment systems. Common Cartridge supports the use of IEEE Learning Object Metadata (LOM), the Dublin Core Metadata Element Set (mapped to the corresponding elements in LOM), and the IMS Question and Test Interoperability (QTI) and Authorization Web Service standards. Tests for compliance with Common Cartridge are available, and the standard has been widely implemented by educational publishers, assessment organizations, and learning platform providers.

The content management component of SCORM 2004 is required in a number of international and U.S. government contexts, as well as in some K-20 domains. A compliance test for SCORM content is available. Both SCORM and IMS Common Cartridge are based on IMS Content Packaging, which has been proposed for international standardization. Including SCORM assets as Common Cartridge assets is relatively straightforward, and IMS has developed an automated conversion tool for certain types of SCORM content.

Exchanging Data

Standard formats for student data – both numerical and descriptive – have immediate benefits when they are used by various instructional and non-instructional software applications in an educational enterprise. Instructional data includes assessment results, grades, transcripts, student portfolios, and student preferences, etc. Non-instructional data includes student demographic information, HR records, institutional financial information, library information, and other institution or system-specific information.

Examples of the use of such interoperable data include the following:

- Easing supply/access of student administrative data between an LMS, a library information system, a financial aid application, an access control system, or another administrative application that implements that standard structure.

⁴ The content itself generally is developed using industry publication or presentation standards such as HTML, Flash, PDF, ePUB, WAV, JPEG, MP4, or Microsoft Office formats, etc. Educational content also often must satisfy accessibility requirements, be aligned with government or professional standards for curriculum or for measuring competency, and include license information for managing rights of use.

- Enhancing the sharing of student performance data between assessment and instructional applications in order to dynamically match learning content to a student's learning needs.
- Enabling the use of several systems from one login interaction (single sign on), such that multiple applications recognize the same username, password, etc.
- Entering data once in a standard structure, such as that maintained in a Student Information System (SIS), to eliminate error-prone and costly multiple data entry.

Exchanging such data is necessary for everything from personalizing instruction to basic administration to longitudinal evaluation of the effectiveness and efficiency of a teaching method or institution. Fine-grained data from student responses also can be analyzed in real time to provide students and instructors with immediate feedback that drives adaptive adjustments to the teaching and learning process, by both human and computer, as that process is underway.

Data Standards

The SIF Association and PESC have produced the most widely adopted standards that specify formats for student and administrative data. These standard formats allow data from multiple sources (e.g. different schools or time periods) to be compared, and they allow data from one source to be shared with multiple applications (e.g., instruction, assessment, and library systems).

The SIF data standard describes the format of student data that is exchanged by a variety of PK-12 administrative applications, such as assessment, food services, student information systems, bus transportation, library automation, professional development, etc.

PESC's data standards address secondary and post-secondary applications directed at administrative scenarios, such as applying for admission, requesting transcripts, and managing student aid. The SIF Association and PESC are collaborating to provide integrated PK-20 standards consistent with the emerging Common Educational Data Standard (CEDS) (See Figure 2 below).

Integrating Educational and Administrative Applications

As noted above, standard formats for content and data are useless without companion standards that support the integration of applications that use the content and data. Educational applications also must be integrated with identity management systems in order to authenticate users and authorize them to perform actions, with digital rights management systems in order to observe the terms of licenses for content and software, and with various other software applications and system services in the school or institution's computing environment.

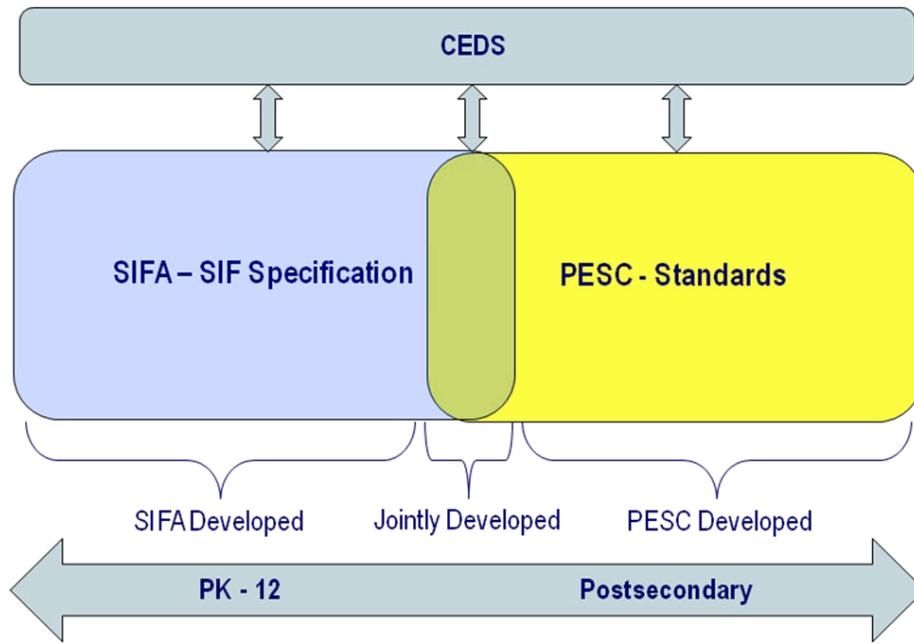


Figure 2. SIF Association and PESC Data Standards

Integration Standards

Educational standards for integrating applications include the SIF Agent and SIF Zone Integration Server standards, IMS Learning Tools Interoperability, and the PESC Data Transport Standard and reference implementation.

PESC's Data Transport Standard (DTS) specifies a Web service architecture that enables applications to send and respond to requests (e.g., transaction, inquiry, and report) using standard web service protocols. DTS is a recommended replacement for common email transfer and file transfer protocols (e.g., POP3/SMTP or FTP).

The SIF standard specifies not only data formats, but also rules and definitions for using a SIF Agent or a SIF Web service to share data within a SIF Zone. SIF Agents are software extensions of underlying applications. A SIF Zone is a logical grouping of applications whose Agents can communicate with each other via a SIF Zone Integration Server (ZIS). The ZIS manages access, routing, delivery, and security within the Zone. A single ZIS can manage multiple Zones, and applications can use SIF Agents or Web Services to communicate within and between different levels in an administrative hierarchy. For example, a state-level data warehouse might publish teacher certification data to district databases and receive updates to its own data from school and district-level data warehouses. (See Figure 3)

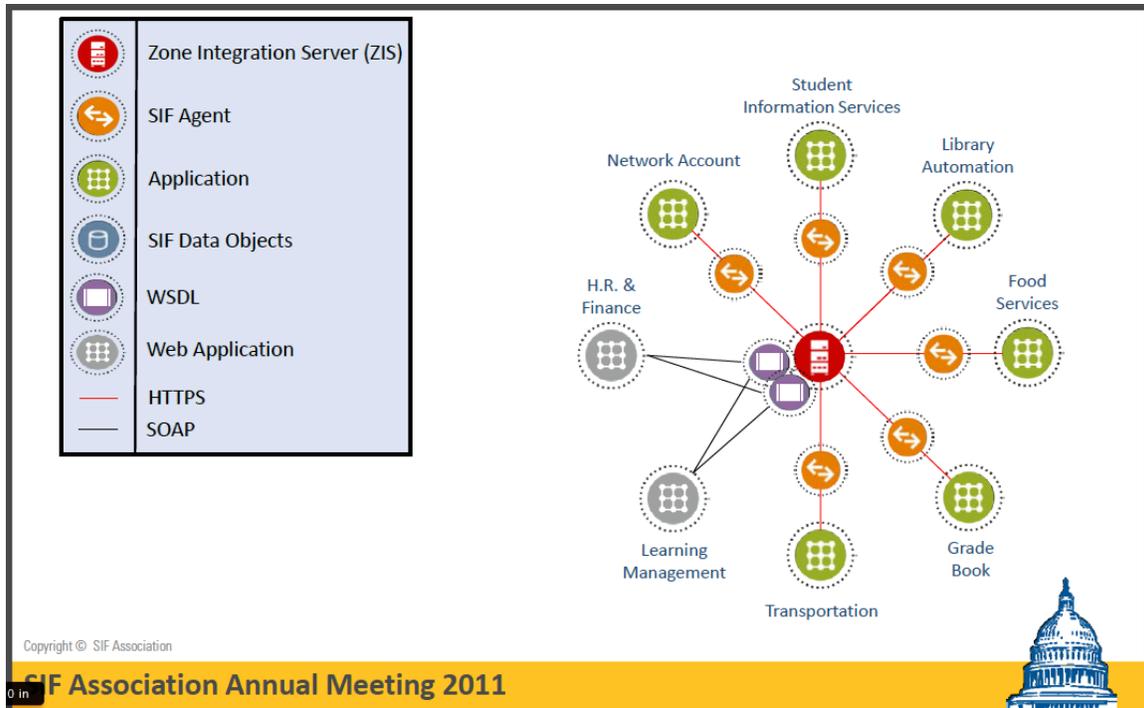


Figure 3. SIF Agents in a SIF Zone

The IMS Learning Tools Interoperability (LTI) standard complements Common Cartridge. It standardizes both access to centrally hosted content and access to programs (e.g., interactives) that are embedded or referenced in the content. It provides a framework for integrating separate learning applications with platforms such as LMSs, eReaders, library information systems, or other web applications. LTI also addresses interoperability among web-based, externally hosted applications, content, or tools. For example, LTI can be used to securely connect an external assessment system or a virtual laboratory to an LMS for testing or for independent study. LTI's role in the educational computing environment is illustrated in Figure 4.

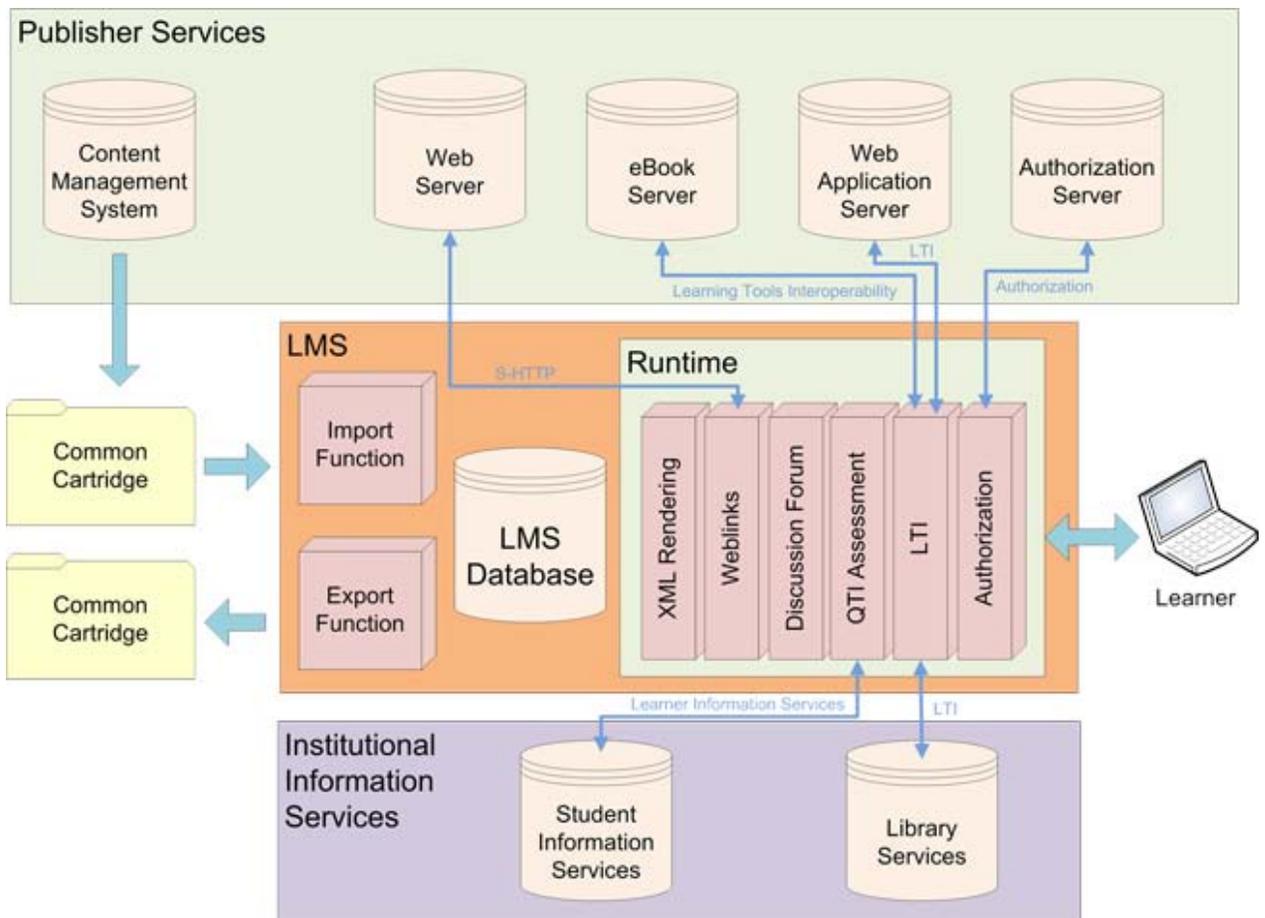


Figure 4. Integrating Content Sources and Software Applications

Special Challenges and Concerns

Accessibility

Education is a domain with special concerns for providing equitable learning opportunities to all students, including students with disabilities. For example, the digital content used in assessments often must meet accessibility requirements, in addition to being aligned with curriculum or competency standards and enforcing license constraints on the use of content or programs. Meeting this constellation of requirements depends on standards for reliably moving content and exchanging data and for integrating educational and administrative applications across many sub-systems.

The Accessible Portable Item Protocol (APIP) provides developers of assessment programs and question items with a standard file format for digital test items. This interchange format allows both tests and items to be moved among compliant test/item banks or to a test delivery platform. A standard format for user accessibility needs (i.e., a profile of the user's interaction preferences) makes these user needs available to the

delivery platform, thereby cueing appropriate rendering and response regimes and enabling accessible assessment of students with a variety of disabilities and special needs.

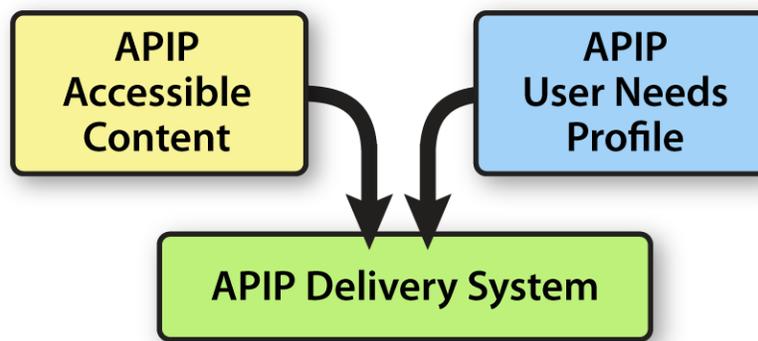


Figure 5. APIP Components

APIP was introduced recently, but its basis for describing accessibility preferences is the existing Content Packaging standard at the heart of the IMS Common Cartridge, and the IMS Access For All Personal Needs & Preferences standard. Accessibility preferences and accessible content are used by the delivery system to tailor, in real-time, the presentation of question items to fit the accessibility needs of the individual student. APIP expands the existing IMS Question and Test Interoperability (QTI) v2.1 specification to create a comprehensive framework that encompasses the requirements for creating accessible tests.

Data Privacy and Digital Rights Management

Protecting the privacy of individuals and maintaining the integrity of student or administrative data involves technical issues that are similar to those for managing the right to use digital content or educational software. Both require an ability to authenticate users and determine whether they are authorized to conduct an activity. Interoperability can challenge management of access to these resources, but current interoperability standards do provide solutions.

Data Privacy

Protecting the privacy of demographic and performance data that is associated with individuals and maintaining the integrity of that data requires an ability to authenticate individual or institutional users and determine whether they are authorized to access a particular database and/or conduct a specific activity. In addition, policies regarding access and use must exist and be enforced, and the 'owner' of the data or software system must receive appropriate notice of the activity that takes place.

The capability to track and control the use of data or software applications by a third party person or system ensures that the integrity of the resource is not compromised through deliberate or accidental misuse, repackaging, repurposing, or sharing. Technical support for policies regulating access and usage allows users to trust systems and

provides both vendors and consumers with a viable model for making data resources available, allowing their use, and managing the resources that are necessary to do so.

Digital Rights Management

Managing digital rights is essential for protecting intellectual property and enabling viable models for commerce involving data and software, as well as for maintaining the willingness of a content creator or a software developer to expose their product in open educational systems. Current interoperability standards provide a format for expressing license restrictions that schools and librarians must manage in order to distribute content or software and enable instructors and students to use them. Software that uses these means for expressing rights and enabling enforcement must implement procedures that allow or prevent the use of content as appropriate.

Controlling Access and Use

Providing interoperability in education raises a concern with authenticating users and authorizing their activities, but these technical and policy issues are not unique to education. The regulatory and legal issues that arise in managing interoperable content, data, and programs in education have their analogues across sectors of the IT industry and are being resolved in sensitive areas such as sharing medical data or exchanging financial information.

In the end, technical standards and their implementations are just tools that help protect privacy and manage identity. Non-technical administrative procedures must complement technical measures in order to restrict interoperability so that privacy is protected and rights are managed. The adequacy of a procedure depends on administrators and users. For example, a password routine can be implemented to provide a lock and key for controlling access to protected content. But the level of protection it provides depends on the procedure for distributing and maintaining user names and passwords being sound and on users following that procedure.

Managing The Way Forward

Consolidating Standards Initiatives

The impetus for standardization typically leads to three kinds of initiatives:

- A regulatory entity or a large consumer encourages or mandates the use of a standard;
- One or more vendors attempt to promote a proprietary approach as a public standard; or
- A consortium of vendors and/or consumers organizes to develop a joint solution to a common problem.

Each kind of initiative has particular objectives and strengths, but none of them can force a standard into practice without another. This is because an effective standard creates an ecosystem in which a cross-section of vendors, consumers, and formal or informal authorities can collaborate to create widespread impact.

Even when such collaboration is underway, standards in a field changing as rapidly as educational technology must continue to evolve. The standards discussed in this Primer have made widespread collaboration possible. They have furthered interoperability and begun to enable meaningful innovation. Consolidation among initiatives and the development of practice that vendors and consumers desire now depends on whether those same vendors and consumers adopt and use interoperability standards.

Re-Setting Developer Expectations

It is worth taking a moment to examine how trends in technology, pedagogy, and commerce have rendered invalid many earlier reasons for delaying or minimizing investment in interoperability.

- **Competition on Services:** Developing a platform to support various instruction, assessment, or administration scenarios and interoperate with a variety of data resources and applications programs requires significant developer investment. In the past, the features of content and the functions of platforms were the basis of competitive advantage. Implementing interoperability was an unnecessary expense, and interoperability was a threat to competitive advantage. But the capabilities of a platform and the features of an item of content are becoming commodities. As educational technology matures, vendors increasingly compete on services, rather than products, per se. Budget pressure and an emphasis on results have shifted the focus of consumers toward services as well. To be successful in current and future markets, developers now must build interoperability into the content and software that they create and accommodate interoperability across platforms.
- **Data Availability:** Data used to be a scarce resource that was unique and expensive to gather. Many instructional, assessment and data applications provide value-added information such as through testing and analytics. Both vendors and education entities were reluctant to share “their” data. But data now can be collected cheaply and easily from virtually any source. The value of an individual source of data to the educational process no longer depends on its existence, but on its availability. The value of an algorithm is in its application across multiple sets of data. Pedagogical assessment and administrative data analysis increasingly require multiple analytic algorithms that access multiple sources. Consequently, it is increasingly necessary for developers to make (and consumers to allow) interoperable data sources and algorithms in order to meet educational and business requirements. When data has value to the educational process, it is increasingly and appropriately recognized as “user data” that should be interoperable.

- **Data and Web Integration:** Developers often expend great effort integrating educational databases and educational software with other data or programs in existing or planned IT infrastructure of an agency or institution. The costs involved cause developers to be cautious about sharing this data and value. Yet, this infrastructure is increasingly web-based. Instead, both producers and consumers are increasingly investing in interoperability so that applications can be assembled cheaply from a variety of components and evolve quickly in response to changing requirements or technical innovation. Investments in interoperability will minimize previous developer integration costs, thus achieving cost efficiency and helping shift resources to value-added educational services.

Re-Modeling Pedagogy and Commerce

Integrated learning systems, adaptive tutors, and other instructional applications are often designed to operate holistically to personalize learning and differentiate instruction. For these systems to reach their potential, content, data, and program interoperability must expand. On the other hand, sophisticated educational resources have intrinsic structure and coherence that may be lost if they are decomposed into discrete, portable learning objects or employed outside the environment for which they are created.

A similar dilemma exists among evolving models for conducting commerce in education. For example, the interoperability of both proprietary and open source digital content and software programs is expanding to make blending multiple instructional, learning, and assessment resources possible.

Changes in pedagogical practice and business models for commerce will continue. Both pedagogy and business are evolving as the educational marketplace seeks a blended and balanced incorporation of educational technology. Interoperability provides the flexibility necessary to make this evolutionary process efficient and consolidate its results. In fact, the interoperability does not force all adaptive learning applications to be decomposed into bite-sized learning objects, or require all content to be portable across systems with conflicting instructional designs or licensing arrangements.

Advocating Interoperability

Educational practice and educational technology are changing rapidly as the transition from print to digital, from physical to virtual environments, and from institutional to personal resources proceeds. Moving forward in educational technology requires all stakeholders to implement interoperability standards as the means for driving efficiency, innovation, and effectiveness. The superficial disorder that naturally arises from a healthy standards ecosystem is not an excuse for delaying the adoption and use of proven standards.

To realize the long-term benefit of educational technology to education and commerce all stakeholders must genuinely embrace interoperability as a goal. Focusing on results will drive improvements in the practical effectiveness of interoperability standards. Those vendors and consumers who fail to adopt and implement interoperability standards will increasingly be left behind. Those who leverage interoperability as an objective will increasingly be successful in meeting their own needs and in helping to achieve the societal goal of greater educational attainment.

Appendix 1: Interoperability Initiatives

This Appendix includes several different kinds of organizations and initiatives that have undertaken the task of improving interoperability. They are grouped into Existing Sources, New Initiatives, and Related Efforts. A brief description of each organization or initiative and its accomplishments or objectives is provided below. Much of the material provided was taken from web sites and other public sources that change over time. To probe further, readers should consult organizational websites and seek additional third-party reviews.

Established Organizations

Advanced Distributed Learning (ADL) and Sharable Content Object Reference Model (SCORM)

The Advanced Distributed Learning Initiative was begun by the U.S. Department of Defense Office of Personnel Readiness to harmonize learning technologies across the military and government agency. In cooperation with several standards organizations, the ADL developed SCORM 2004, a “Sharable Content Object Reference Model” that integrates IMS GLC content packaging, IEEE LOM metadata, AICC runtime communication and data tracking, and IMS GLC simple sequencing. SCORM enables the interoperability and reusability of Web-based content in multiple learning management systems.

ADL’s Content Object Repository Discovery and Registration/Resolution Architecture (CORDRA) is an open, standards-based model designed to support an interoperable federation of independent content repositories, and is the technical basis for the Learning Registry Initiative. (See www.adlnet.gov)

The Dublin Core and the Dublin Core Metadata Initiative (DCMI)

The Dublin Core is a set of metadata elements that provide 15 base text fields that can be used to describe physical resources such as books and digital materials such as videos or web pages. Metadata records based on Dublin Core are intended to be used for cross-domain information resource description and have become standard in the fields of library science and computer science. Dublin Core data uses XML and is based on the Resource Description Framework (RDF).

The Dublin Core Metadata Initiative (DCMI) is an open organization working on the development of interoperable metadata standards that support a wide range of business models. The DCMI works to provide standards that facilitate finding, sharing, and managing information. Their work also involves the development of international standards for describing resources, supporting users and developers, and promoting the use of Dublin Core.

The DCMI began in the 1990s and now has members from around the world. They encourage the adoption of the Dublin Core in both public and private sector activities. Their standards are focused on semantics – how information resources are described – and their work assumes that the technological infrastructure will continue to evolve. Their focus is on the discovery of resources across the boundaries of information silos on the Web and within intranets.

The key attributes of the Dublin Core are:

- Simple and generic resource descriptions. The fifteen-element "Dublin Core" achieved wide dissemination as part of the Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) and has been ratified as IETF RFC 5013, ANSI/NISO Standard Z39.85-2007, and ISO Standard 15836:2009.
- Application profiles. Metadata records would use Dublin Core together with other specialized vocabularies to meet particular implementation requirements. As part of an extended set of DCMI Metadata Terms, Dublin Core became one of the most popular vocabularies for use with RDF, more recently in the context of the Linked Data movement.
- Simple, semantic interoperability. These are agreed upon by the international community, interdisciplinary, and can be used for any format. It is both extensible and modular. The Dublin Core standard includes two levels – “Simple” and “Qualified.” “Simple” comprises the 15 elements and “Qualified” includes additional elements such as audience, provenance, and the rights holder.

The DCMI was incorporated in Singapore in 2009 and is now an independent non-profit corporation. Work on the standards is carried out and maintained by a standing Usage Board and international conferences are held annually. The DCMI pairs with NISO to provide Webinars and other information to the user community. Dublin Core is recognized as one of the core vocabularies for the Semantic Web and is one of the main players in terms of Linked Data. (See www.dublincore.org)

IMS Global Learning Consortium (IMS GLC)

IMS began as a project within the National Learning Infrastructure Initiative of EDUCAUSE and became an independent non-profit organization called the IMS Global Learning Consortium in 1999. IMS GLC is a nonprofit, member-funded organization that engages in community development of standards, promotes innovation in educational technology, and facilitates research into best practices. The suite of IMS specifications broadly addresses "distributed learning" in elementary, middle, and secondary higher education, and further learning environments.

IMS GLC has developed and released individual learning content and system specifications that address content packaging, metadata, accessibility, competency definitions, digital repositories, enterprise services, learner information, learning design, assessment, and other components of system interoperability. These standards are used in higher education, K-12 education, and corporate education. In recent years, the

organization has focused on consolidating individual standards and increasing standards use through alliances that support vendors and consumers, application development, and participating in collaborative efforts to broaden the scope of standardization throughout the education industry. All IMS GLC standards are available free of charge via the IMS GLC web site. (See www.imsglobal.org)

IMS Common Cartridge combines several content and packaging standards to create a comprehensive standard for content portability and interoperability. Common Cartridge is made up of elements from IMS GLC content packaging, question and test interoperability (QTI), learning tools interoperability (LTI), and Learning Object Metadata (LOM). It also includes interoperability services for integration of authorization and discussion forums. (See www.imsglobal.org/commoncartridge.html)

The Common Cartridge defines a package interchange format for learning content, to be run on any compliant LMS platform. A tool for testing cartridges for conformance with the specification is available. The Common Cartridge and Learning Tools Interoperability Alliance provides a number of resources to help software developers implementing the specification, content authors creating cartridges, and user institutions and practitioners deploying Common Cartridges.

Postsecondary Electronic Standards Council (PESC)

The Postsecondary Electronic Standards Council (PESC) was established in 1997 by stakeholder organizations at the National Center for Higher Education in Washington D.C. as a non-profit association of colleges, universities, professional and commercial organizations, non-profit organizations, government agencies, and data, software, and service providers. The goal of PESC is to enable cost-effective connectivity between administrative data systems in order to accelerate performance and service, simplify access to data, and facilitate research. PESC promotes the implementation and use of data exchange standards, but does not set policies on privacy and security.

Components of the PESC suite of standards and other products are available on the PESC website (see www.pesc.org) and include:

- An Admissions Application that can be used to send admissions data to colleges and universities.
- An Education Test Score Reporting standard that can be used by any testing agency or affiliated third party such as employers, research facilities, or government agencies.
- Schemas for student-based survey categories of the Integrated Post-secondary Education Data System (IPEDS) used to report survey data to the National Center for Educational Statistics (NCES).
- A Federal Student Loan and Grant standard used by FSA and every college and university in the country with students receiving federal student loans and grants (PELL grant, Stafford Loans, etc.).

- A High School and College Transcript Standard used for admissions, transfer, and employers being implemented throughout the US and Canada.
- A data transport specification.
- A PDF attachment standard that lets senders and receivers exchange any content in PDF format.
- Course Catalog, Recruitment and Enrollment, and NSDLS standards are in the final stages of development and will be released within 6 months.

PESC has three active Task Forces as well: EDunify, working on an open directory for web services, Common Data Services, focusing on EDexchange development of a national exchange model and service, and Electronic Authentication/Electronic Authorization (EA2), focusing on EDadmit me development of a single-sign on protocol for postsecondary.

Schools Interoperability Framework Association (SIF Association)

The SIF Association is a non-profit membership organization whose members include software vendors, school districts, state departments and ministries of education, and other organizations active in primary and secondary (pK-12) markets. The organization develops rules and definitions, collectively called the SIF Implementation Specification, that enable software programs from different companies to share information. (See www.sifassociation.org)

SIF is a data interchange standard that has been under development for over 15 years. The use of SIF makes it possible for separate programs within a school, district, or regional enterprise to share data with less in-house programming and without requiring vendors to directly support other vendors' applications.

A SIF Zone consists of a Zone Integration Server (ZIS) and a SIF Agent for each networked application. The ZIS is a program that provides services to which Agents (or web services) can subscribe in order to publish events, provide data, and make or respond to requests. The ZIS controls access and routing within the Zone. The ZIS functions as a trusted intermediary for complex communications between agents that have no direct communication or knowledge of each other's underlying applications.

Historically, SIF provided both a data model and data transport architecture. The most recent release of the specification separates the two and embraces web services as an alternative to SIF-specific transport standards.

SIF provides data standards for school practices and educational applications in two different categories, administrative and instructional. The administrative category includes food services, student information systems, bus transportation, library and textbook automation, network accounts, data warehouse, telephony and human resources, and financial management. Instructional applications include grade book, instructional services (learning management systems, content management systems, and instructional management systems), professional development, assessment, data analysis tools, and special programs.

Version 2.5 of the SIF Implementation Specification has been released, and refinement of the standard continues.

New Initiatives

Common Education Data Standards (CEDS)

CEDS specifies commonly used data elements to support the effective exchange of data within and across state education systems. This exchange of information is necessary for tracking students' movement between educational sectors and levels, and is necessary for federal reporting. Adoption of CEDS will enable more consistent and comparable data to be used to improve student achievement. CEDS is being developed by the National Center for Educational Statistics (NCES). The voluntary CEDS Stakeholder Group includes representatives from states, districts, institutions of higher education, state higher education agencies, early childhood organizations, federal program offices, interoperability standards organizations, and key education associations and non-profit organizations. CEDS Version 2.0 (CEDS 2.0) is expected to be released in January 2012. CEDS 2.0 will include a data dictionary, a logical data model, an XML schema (for data-at-rest), and a set of tools to help states map their current data systems to the new standard. (See <http://nces.ed.gov/programs/ceds/>)

Ed-Fi

Ed-Fi is a free K-12 open XML-based data standard from various sources for consolidating student data between information systems. Ed-Fi is funded by the Dell Foundation, and its purpose is to integrate data from SIS, grade book apps, curriculum planning systems, and testing/reporting systems. Data can include grades, absence rates, transcripts, test scores, accounting, and human resources systems as well. Version 1.0 was released in January, 2012. (See <http://www.ed-fi.org/>)

Key attributes of Ed-Fi include:

- Bringing together performance data across classrooms, districts, schools, states, and also for individual students.
- Providing a unifying data model with a central XML schema definition (XSD) that defines common data elements including attributes, types, and structures.

- Using a data exchange framework or interchange schemas that depend on core schema and serve as connectors to send and receive information among systems. Vendors can create new interchange schemas to accommodate new scenarios.
- Using an application framework (extension schemas) to accommodate new types of data to be added, such as SEA or grant reporting data.
- Including sample web-based dashboards such as an example relational database model and metrics needed to define performance management indicators. Ed-Fi provides elements to build dashboards.

Ed-Fi is compatible with existing national and local standards including the Common Educational Data Standard (CEDS). It shares some characteristics with other educational standards (SIF, PESC, NEDM, NCES), but is more teacher- and student-centric. The purpose of Ed-Fi is not to replace, but to augment existing systems. Ed-Fi focuses on student performance and actionable intelligence (i.e. student level data and vertical reporting), is responsive to evolving reporting requirements, and has data elements with “plain English” names to make it easier to use. It is compatible with many vendors and contains over 400 data elements. Ed-Fi XML Core Schema Principles are adapted from PESC Guidelines for XML Architecture and Data Modeling. Five states (Colorado, Delaware, Louisiana, Tennessee and Texas) are participating in the development of Ed-Fi.

Learning Registry Initiative (LRI)

The Learning Registry Initiative (LRI) is a collaboration among several federal agencies to create a public social metadata distribution network that will make federal learning resources and primary source materials easier to find, access, and integrate into educational environments. The key members of LRI include Advanced Distributed Learning (ADL) and the U.S. Department of Education. The group is working with other federal agencies such as NSF, OSTP, FCC, NIST, NARA, and NASA, as well as with IMLS and large non-government group including the National Science Digital Library, ISKME/OERCommons, PBS, BBC, Connexions, Sakai, and various British and Australian organizations. (See <http://www.learningregistry.org/>)

Instead of providing separate portals for each learning resource, the goal is to build a learning layer on Web 2.0 by combining resources, context, and data to support discovery of learning resources through a common set of public APIs and Web 2.0 data. The resource distribution network will include open APIs that anyone can use to expose or consume learning resources and information about how they are used. It will enable building a business-to-business infrastructure where users can find, share, use, and augment available learning resources. Organizations can build third-party applications and communities on top of this distribution network to facilitate learning resource discovery, access, and sharing.

The Learning Registry hosts and shares both metadata and paradata (content about where a learning resource was used, comments, rankings, ratings, etc.), i.e., it provides “social networking for learning resources.” It combines cataloging information, usage,

assertions, data exhaust, and analytical data into a single, sharable timeline for learning resources.

The design of the LRI is based on web 2.0, including RESTful interfaces (REST, 2000), JSON data structures (JSON, 2006), NoSQL databases (NoSQL, n.d.), map-reduce computation (Dean 2004), and open APIs. Any schema and type of metadata or paradata is permitted, e.g., IEEE LOM, METS, or Dublin Core. The resource data may be in any form: JSON, CVS, XML, binary, etc.

An initial public distribution network based on 0.2x code was released in June 2011, and the Learning Registry was formally launched in November 2011. Partner integration and support for the development of user communities, value added services, and tools are also planned.

Learning Resource Metadata Initiative (LRMI)

The Learning Resource Metadata Initiative (LRMI), formed in June 2011, is a project to create a common vocabulary for describing learning resources on the Internet. The LRMI is co-led by the Association of Educational Publishers and Creative Commons and is funded by the Bill & Melinda Gates Foundation and the William and Flora Hewlett Foundation. (See <http://www.lrmi.net/>)

The goals and activities of the LRMI include:

- Documenting an abstract vocabulary representing the most common descriptions of learning resources used by existing educational metadata standards and by online publishers of learning resources and addressing the desire to link learning resources to learning outcomes.
- Creating a concrete expression of the abstract vocabulary for use within the schema.org hierarchy.
- Creating a concrete expression of the abstract vocabulary as RDF, for interoperability with other applications and existing vocabularies so that explicit equivalences and refinements may be established, protecting existing investments in educational metadata.
- Promoting adoption and impact of the vocabulary through liaison with search engines, learning resource publishers, communities, and repositories, and other potential distributors and consumers of education metadata.
- Explaining the impact, value, and use cases of a common education metadata vocabulary to the general public, as well as decision and policy makers.

In August 2011, LRMI announced the formation of its technical working group, which includes representatives from leading experts in the fields of education, publishing, and metadata. The role of the group is to create a metadata framework for tagging learning resources light enough to be easily implemented, but rich enough to assign valuable attributes to educational content so that searching and filtering will be easier for educators and students.

Once the work is complete, the technical working group will submit their framework to be considered for adoption under the Schema.org initiative. If accepted, the LRMI framework would become the de facto standard for tagging learning resources online. Finally, the technical working group will make recommendations for long-term governance of the standard.

Schema.org

Schema.org is a collaborative project formed in June 2011 by Google, Bing, and Yahoo! It provides a collection of schemas (i.e., html tags) that can be used to markup pages in ways that are recognized by major search engines. Schema.org provides a shared markup vocabulary for webmasters. (See <http://schema.org>)

Key attributes of Schema include:

- Schema enables search engines to access the information on web pages by formatting data stored in databases into HTML via on page markup. Markup can enable new tools and applications to use the structure also. The schemas are a set of 'types', each associated with a set of properties, and the types are arranged in a hierarchy and are all available on the project web site.
- Schema uses microdata instead of RDFa or microformats, because microdata offers an open extensibility mechanism and is not too complex to use. Schema microdata allows for a wider range of “Rich Snippets” that can be used across major search engines. This microdata allows for more visually rich search-engine ranking pages, and the prediction is that Bing and possibly other search engines will use this microdata as a direct ranking signal.
- The Schema extension system can be used to define a new type.

This initiative was announced in June of 2011. Currently Schema is in draft form (version 0.90) and is soliciting feedback. LRMI is an education specific extension to Schema.

Shared Learning Infrastructure (SLI)

The Shared Learning Infrastructure (SLI) is being developed through funding from the Carnegie Foundation and the Gates Foundation, working in partnership with the states of New York, Illinois, Massachusetts, North Carolina, and Colorado. The work is being coordinated through the Council of Chief State School Officers (CCSSO) and hosted by a separate entity called the Shared Learning Collaborative. (See <http://www.slcedu.org/>)

The SLI is designed to help educators address the Common Core standards through access to resources, data, and tools. This shared service will include a data store, related analytical and reporting services, and a set of APIs to enable interoperability with third party information systems, learning applications, and content. All applications and tools will be aligned to the Common Core State Standards. The SLI will be rolled out with a generic user interface, but many school districts will probably choose to create a custom

interface. The software will be open for third party use and reuse.

The key attributes of the SLI are:

- A cloud-based data integration and aggregation service that provides a layer of interoperability to capture, warehouse, aggregate, and report data to educators and vendors about student progress. The service will provide data loading tools so that districts can integrate their existing systems into a single, secure SLI data store.
- A set of APIs that enable application developers, courseware designers and educators to access data and share resources and enable users to access new and existing “apps stores” that will give teachers and students access to the latest user-rated tools and content.
- A content services layer that links to courseware, content repositories, and assessment tools from many providers both free and for-fee. Queries to the SLI data store will be enabled through both the Learning Registry and the Learning Resource Metadata Initiative.
- Learning maps that will be developed by Applied Minds and based on more granular learning objects that underlie the Common Core Standards. These maps will allow teachers to track individual student learning and connect to relevant content and tools. An open source-authoring tool will allow third party developers to create learning maps as well.

The SLI will launch with an initial set of third-party content resources to demonstrate functionality and value. Multiple vendors are currently receiving contracts to work on the project and the project was recently set up as an LLC, but in the long term the software will be owned and managed by an independent nonprofit. The SLI project team intends to license Ed-Fi as the basic data model. SLI will be made available in a free, open format through an open license to all, including public, non-profit and for-profit entities.

Related Initiatives

Common Core State Standards (CCSS)

Curriculum standards include benchmarks or other discreet elements that define the goals of student academic knowledge and skills. Curriculum standards are not technical standards in the context of interoperability, but they can be tagged with metadata to facilitate their interoperability in terms of making explicit connections to content, assessment items, and other data. CCSS is a state-led initiative to create a shared set of clear K-12 educational standards for English language arts and mathematics that states can voluntarily adopt. The standards have been created by building from the highest state standards across the country, with input from a diverse group of teachers, experts, parents, and school administrators. The initiative was led by the National Governors Association (NGA) and the Council of Chief State School Officers (CCSSO). The standards provide clear and consistent benchmarks that can be used to ensure students graduating from high school are ready for college or career, and are internationally

competitive. Currently all but six states have adopted the Common Core State Standards. (See <http://www.corestandards.org/>)

Creative Commons (CC)

Creative Commons (CC) licenses allow the creator or publisher to retain ownership of the copyright while allowing others access to use and modify that work in a fashion consistent with the CC license the owner selects. These licensing options include making the resource available to others for their commercial use, consenting to modify and create derivative works, and selecting the countries in which the permissions apply. By combining these and other variables, many different licenses can be created to address a spectrum of needs and provide various levels of permissions pertaining to the use and reuse of the materials described. The CC is thought to address many of the ambiguities left unanswered by 'fair use' terms in existing copyright law. (See <http://creativecommons.org>)

PARCC

The partnership for Assessment of Readiness for College and Careers (PARCC) consists of a consortium of states working collaboratively to build a common set of K-12 assessments for English-Language Arts and Mathematics focused on college and career readiness and success. PARCC (along with SBAC) is funded through a grant from the U.S. Department of Education Race to the Top program. PARCC assessments will track students' progress toward high school graduation beginning in third grade and provide information to inform instruction and provide support. The PARCC assessments will be ready for states to administer in 2014-2015. Twenty-five states currently participate in PARCC. (See <http://www.parcconline.org/>)

Key Attributes of PARCC are building a K-12 assessment system that:

- Builds a pathway to college and career readiness for all students.
- Creates high-quality assessments that measure the full range of the Common Core State Standards.
- Supports educators in the classroom.
- Makes better use of technology in assessments.
- Advances accountability at all levels.

SBAC (Smarter Balanced Assessment Consortium)

SBAC is one of two multistate consortia (along with PARCC) funded by the U.S. Department of Education to develop an assessment system based on the Common Core State Standards (CCSS). The goal of SBAC is to create a balanced set of measures that will provide student data throughout the academic year that will inform instruction and guide interventions. SBAC includes a professional development component to help teachers use the assessment to inform teaching. Currently 33 partner states are working with SBAC. (see <http://www.k12.wa.us/smarter/>)

Key attributes of SBAC include:

- Mandatory comprehensive accountability measures, including computer adaptive assessments, which will be administered during the last 12 weeks of the school year in grades 3 through 8 and in high school.
- Providing valid measures of students' progress toward skills and knowledge required to be college and career ready.
- Making use of technology affordances for adaptive testing and quick turnaround of results.
- Providing composite content area scores.
- Combining a variety of assessment types to cover the full range of English and math standards.
- Providing research based support, technical assistance, and professional development to teachers using the assessment data to inform instruction.

Appendix 2: Interoperability Concepts and Terms

The world of interoperability is a complex ecosystem with multiple terms, organizations and regulations. This professional jargon is often impenetrable for vendors and consumers. Brief discussions of concepts and terms that characterize educational standards and interoperability are included in this Appendix.

API

An application-programming interface (API) is a particular set of rules and specifications that software programs can follow to communicate with each other. It serves as an interface between different software programs and facilitates their interaction, similar to the way a user interface facilitates interaction between humans and computers. The term API may be used to refer to a complete interface, a single function, or even a set of APIs provided by an organization.

An API can be created for LMS's, digital libraries, databases, etc., as a way of defining their "vocabularies" and conventions requesting resources. It may include specifications for routines, data structures, object classes, and communication protocols used to communicate between consumer and provider programs.¹

The API can be written to be called using several programming languages. This is a desirable feature for an API that is not bound to a specific process or system. For example, a website that allows users to review local restaurants is able to layer their reviews over maps taken from Google Maps, because Google Maps has an API that facilitates this functionality.

Authentication

Authentication refers to who (which person or system) may access the information – whether content or data. Authentication is essential for maintaining the integrity of systems that open their content data to one another. It includes data for authenticating users or systems that wish access to data provided by a compliant system.

One familiar use of authentication is access control. Access is usually controlled by insisting on an authentication procedure to establish with some degree of confidence the identity of the user before granting privileges established for that identity. Common examples of access control involving authentication include:

- Asking for photoID when a contractor first arrives at a house to perform work.
- Using a program to determine that a user is a human being and not a computer program.
- Using a security code.
- Using a name and password.
- Using email exchanges to verify ownership of an e-mail address.

Experts argue that it is impossible to prove the identity of a computer user with absolute certainty. The problem is to determine which tests are sufficient for balancing ease of use against the strictness of the access checks. For example, a credit card network does not require a personal identification number; small transactions do not even require a signature for proof of identity. The security of such a system is maintained not by technology, but by limiting distribution of credit card numbers, and by the threat of punishment for fraud.

Authorization

Authorization refers to the usage rights granted to use or modify specific content or a specific application. For instance, digital content may be authorized for use by teachers and students in one course but not in another, or for a single user or an entire school or district. Authorization involves verifying that an authenticated user has permission to perform certain operations or access specific resources. Authentication, therefore, must precede authorization. For example, when you enter a bankcard and personal identification number at an ATM (authentication), you are asking to be authorized to act as the account holder for a specific account.

Content Packaging

Content packaging refers to the way in which learning objects are combined into meaningful, portable instructional units. Content packaging standards include metadata that enables the transfer of collections of content from one compliant system to another through a *manifest* that describes what objects belong with this particular piece of curriculum. A content package would include the content or learning object(s) itself as well as the associated metadata.

Digital Rights Management (DRM)

The Digital Millennium Copyright Act (DMCA) implements World Intellectual Property Organization (WIPO) treaties and addresses significant copyright-related issues concerning infringement, exemptions, and provisions relating to distance education, as well as exceptions for libraries and for making ephemeral recordings or webcasts of sound recordings on the Internet. A complete understanding of any provision of the DMCA requires reference to the text of the legislation itself. While it is not widely used, the IEEE Learning Technologies Standards Committee has established a Digital Rights Expression Language that enables content creators to associate with each learning object the conditions under which a learning object can be used, reused, distributed, manipulated, or transformed.

ePUB

ePub is the key IDPF standard. It is a distribution and interchange format standard for digital publications and documents. EPUB defines a way of representing, packaging, and

encoding structured and semantically enhanced Web content. It includes XHTML, CSS, SVG, images, and other resources that can be distributed in a single-file format. EPUB allows publishers to produce and send a single digital publication file through distribution, and offers consumers interoperability between software/hardware for unencrypted digital books and other publications.

Family Education Rights and Privacy Act (FERPA)

A key distinction of education records is that education records are shared. The federal FERPA (Family Education Rights and Privacy Act, enacted in 1974) is a set of regulations that applies to those institutions that receive funding from the U.S. Department of Education. FERPA was written specifically for students and guarantees them the right to inspect and review their education records, the right to seek to amend education records, and the right to have some control over the disclosure of information from those education records. An education record is defined as any record that directly identifies a student and is maintained by the institution or educational agency or by a party acting for the institution or educational agency. (See <http://www2.ed.gov/policy/gen/guid/fpco/ferpa/index.html>)

HTML

HTML in general and HTML5 in particular is a language for structuring and presenting content on the Web. It is the fifth revision of the HTML standard and is still under development. It differs significantly from previous versions. The goal of HTML5 is to improve the language used to support the latest multimedia while remaining easily readable by humans and understood by computers. HTML5 will subsume earlier versions of HTML as well as JavaScript. It includes detailed processing models to support more interoperable implementation and it improves on the markup available for documents. HTML5 introduces markup and APIs for complex web applications. Specifically, HTML adds a number of new syntactical features to describe different multimedia elements such as video and audio without having to use proprietary plugins and APIs. It also uses new elements that enrich the semantic content of documents through richer descriptions.

Flash

Adobe Flash (formerly Macromedia Flash) is a multimedia platform used to add animation, video, and interactivity to web pages. Flash is frequently used for advertisements, games and animations. Recently Flash has been positioned as a tool for "Rich Internet Applications" ("RIAs"). Flash manipulates vector and raster graphics to provide animation of text, drawings, and images. It supports bidirectional streaming of audio and video, and it can capture user input from a mouse, keyboard, microphone, or camera. Flash contains an object-oriented language called ActionScript and supports automation using Javascript Flash language (JFSL). Flash content can be displayed on different computer devices using Adobe Flash Player.

IEEE LTSC

The Institute of Electrical and Electronics Engineers Learning Technologies Standards Committee is chartered by the IEEE Computer Society Standards Activity Board to develop internationally accredited technical standards, recommended practices, and guides for learning technology. (See <http://ieeeltsc.org/>)

Learning Object/Resource/Asset

These terms are used to describe a “raw” unit of digital content such as a video clip, text passage, science simulation, audio file, or test item. Learning resources are the building blocks of curricula, but without extensive tagging using a common taxonomy, they are difficult to efficiently search for or reuse. Learning Objects are very flexible but require considerable support to be useful. Most notably, they require *Packaging* standards that define how a collection of learning objects can be combined into activities, units, and courses and *Sequencing* standards that define the order in which a group of learning objects are delivered to a student, and under what conditions. Learning Objects are embeddable into other programs, and they can be combined and referenced to build other learning objects.

Learning management system (LMS)

A Learning Management System (LMS) is an application that, as the name implies, helps teachers and administrators manage digital learning. Instructional Management Systems (IMS) are a close cousin, often used more in K-12 education. In the paper-based world, the “LMS” consists of lesson plan books, grade books, scope and sequence tables, seating charts, IEP forms, and so on. In the digital world, an LMS manages student rosters, course descriptions and assignments, lesson plans, learning resources, assessments and so on. LMSs come in two general flavors: generic/independent (e.g., Blackboard, Moodle, Learning Village) and product-specific (e.g., Compass Odyssey, Plato Pathways, Destinations Success, Scholastic Achievement Manager). As administrative and content standards begin to take hold, it is the LMSs where the benefits will be most obvious. Likewise, Content Management Systems and Content Distribution Systems will also play a more beneficial role within the classroom workflow when integrating content from various sources along with assessment items and results, alignment to learning standards, etc.

Learning Object Metadata (LOM)

The IEEE 1484.12.1 – 2002 Standard for Learning Object Metadata (LOM) describes “learning objects.” Relevant attributes of learning objects described include: type of object; author; owner; terms of distribution; format; and pedagogical attributes, such as teaching or interaction style. LOM was derived from the IMS GLC Metadata specification. Core aspects of this standard are incorporated into SCORM and Common Cartridge. LOM is not a competitor or alternative to either SCORM or IMS Common Cartridge.

Metadata

Data that describe, define, or reference the data that is of primary interest regarding a learning object, resource or data element. For example, metadata about a textbook might include the publisher or author name, the date the lesson was created, use rights associated with the lesson, and so on.

NCES

The National Center for Education Statistics (NCES) is the primary federal entity for collecting and analyzing data related to education. (See <http://nces.ed.gov/>)

PDF

Portable Document Format (PDF) is an open standard for document exchange. Created in 1993 by Adobe Systems, PDF is used for representing documents in a manner independent of application software, hardware, and operating systems. Each PDF file encapsulates a complete description of a fixed-layout document including text, graphics, fonts, and other display information. PDF is now a published ISO standard. Anyone is allowed to create applications that can read and write PDF files without having to pay royalties to Adobe Systems. A PDF is a combination of three technologies: a subset of the PostScript page description programming language for controlling layout and graphics, a font-embedding system to allow fonts to travel with documents, and a structured storage system to group these elements into a single file with data compression when needed.

Scope and Sequence

Scope and sequence allow a learning object to be taught within a specific instructional context or at a specific time and place within the broader lesson. If a learning object is designed to be used within a context but is used outside of that intended context, it may lose some of its original instructional value. In relation to interoperability, the challenge of scope and sequence is to be able to create a data model that indicates under what circumstances a particular learning object is most appropriate.

Section 508

Section 508, an amendment to the United States Workforce Rehabilitation Act of 1973, is a federal law mandating that all electronic and information technology developed, procured, maintained, or used by the federal government be accessible to people with disabilities. Technology is deemed to be "accessible" if it can be used as effectively by people with disabilities as by those without. To demonstrate that a product or Web service is in compliance with Section 508, the creator completes a Voluntary Product Accessibility Template (VPAT), an "informational tool" that describes exactly how the product or service does or does not meet Section 508 standards.

The scope of Section 508 is limited to the federal sector. It includes binding, enforceable standards, as well as compliance reporting requirements and a complaint procedure. Section 508 doesn't apply to the private sector, nor does it impose requirements on the recipients of federal funding. Because the federal government has so much purchasing power, however, it is hoped that Section 508 will encourage the development of products and Web-based services that meet accessibility standards. To that end, the United States Department of Education now requires states funded by the Assistive Technology Act State Grant program (a grant program that supports consumer-driven state projects to improve access to assistive technology devices and services) to comply with Section 508. (See <http://www.section508.gov/> and <http://www.access-board.gov/508.htm>)

Simple Sequencing

This SCORM specification defines a method for representing the intended behavior of a learning object such that any learning management system (LMS) can sequence discrete learning activities in a consistent way. The specification defines the required behaviors and functionality that conforming systems must implement. It incorporates rules that describe the branching or flow of instruction through content according to the outcomes of a learner's interactions with content.

Single Sign On (SSO)

Single sign-on (SSO) is the ability for users to access multiple software applications from multiple sources and vendors by logging in just once with a single username and password, preferably from any location. For example, the credentials passed by the SSO system may include a student's unique identification number as well as the student's grade level, NCLB subgroup membership, and other pertinent demographic data maintained by the district's Student Information System (SIS). LDAP and similar protocols make single sign-on possible within enterprises like school districts where there can be a single user directory (typically fed by the SIS).

SSO solves two problems. First, the user only needs to remember one username and password to access the system, rather than enter a new username and password each time a new module within the system is accessed. Second, once the user is logged in, she can transparently move from one module to another even though they may be from different providers. As the user moves from application to application, each application recognizes the access rights and attributes associated with each user.

VPAT

Many vendors voluntarily provide information about the accessibility of their products using a standard web-based template known as the Voluntary Product Accessibility Template™, or VPAT™. The VPAT assists federal contracting and procurement officials in fulfilling the market research requirements contained within Section 508 regulation, and organizations outside of the federal government (e.g., educational entities) are finding the VPATs to be a useful tool for procurement decisions.

XML

XML is an eXtensible Markup Language commonly used in a wide variety of applications. Its primary purpose is to facilitate the sharing of data across different information systems, particularly systems connected via the Internet. XML is the technical meta-tagging language of many interoperability standards.