Primer on Open Technologies in K-12 Education

INTRODUCTION

Technologists love to coin terms and create handy acronyms. For those attempting to make wise planning and purchasing decisions for education technology the terminology can become more of a barrier than an asset. The words "open", "source", "standards", and "interoperability" and combinations of these terms represent specific ideas cherished by various organizations or communities. To an outsider the terms may appear to have overlapping meaning and functionality; yet to each sponsor they are as different as night and day. As a technology planner, you want to make sure that the systems and software that you purchase today fulfill your immediate requirements and are compatible with your institutional environment now and in the future. Open standards represents a bright hope to tame the complexity of school technology and make applications work together efficiently and powerfully. This paper begins to sort out the emerging standards, their respective sponsors, and terminology associated with each standard. It is our goal that this information will help you investigate and answer some initial questions regarding these standards and how they are relevant to the infrastructure decisions you have to make.

"OPEN SOURCE" VERSUS "PROPRIETARY": IMPLICATIONS FOR SCHOOLS

The fast pace of change in the area of educational technology has given nearly everyone the "bleeding edge" experience of adopting software that was incompatible with existing programs, failed to function as planned, or became obsolete overnight. Much of this was due to the proliferation of proprietary programs and operating systems that appeared to deliberately create barriers to the exchange of information between systems and applications. To be fair, software developers are pressed between contradictory requirements. They must be able to make a profit while taking advantage of the latest hardware, providing seamless data exchange between suites of applications, maintaining backward and forward compatibility, and managing releases that are timely, feature-significant and bug-free. Major software companies have traditionally considered their un-compiled "source code" top secret and highly confidential and, therefore, have had to cover all the expenses of development, testing and debugging via maintenance fees from customers and through internal funding. "Proprietary" software development encourages very efficient, tightly

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controlled, and high quality products that work optimally within a single vendor's suite. And yet, even with these controls, there can still be internal compatibility problems.

The "open source" software movement evolved as a philosophical and practical rebellion to the closed architecture of proprietary software systems. Open source software is constructed from applications and source code libraries, which are available at no charge and are continually being tested, expanded, and improved by a diverse community of volunteer and industry supported programmers. Open source software is often distributed under an agreement such as the GNU Public License (GPL) to keep development in the public domain. (GNU stands for "GNUs not Unix, a project of the Free Software Foundation.[1]) Open source developers pool their resources and share underlying technologies that they would otherwise have to reinvent individually. Ideally, this drives the products to differentiate themselves in the market by superior support and integration. The popularity of the Linux operating system demonstrates how ready the market is for open source software. Although Linux is freely available in many different flavors, many developers and users still purchase it from companies such as RedHat[2] or Novell[3] in order to get full product support and regular updates. Other open source projects such as MySQL[4], Perl, and PHP[5] have equally devoted groups of developers.

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School districts usually do not have the technical depth or budget to invent their own applications and systems internally. Instead, they buy pre-packaged solutions from vendors with service and maintenance agreements. The underlying technology, whether it is open or closed, is often transparent to the technology buyer. School technology planners always have to consider Total Cost of Ownership (TCO) when choosing any software. An initial low purchase cost for a system can be offset easily by higher installation, training, maintenance, and support costs. Predicting maintenance costs of a new software implementation is very difficult regardless of whether the software is open source or proprietary. Many schools that have ventured into Linux computing report a steep learning curve, but eventual satisfaction with the reliability and inherent cost savings. Some schools may find it cost-effective to use open source software, but to pay for professional support and systems integration. This also protects schools from being crippled by the loss of key IS staff who know the system.

OPEN SOURCE SOFTWARE IN SCHOOLS

The most visible open source application in K-12 schools is Linux. Servers using this free or low-cost operating system are appearing on school networks. Sometimes dedicated Linux servers are employed to host particular applications; while Linux is the backbone of the entire network in some school districts. An assortment of applications is built on the Linux platform including Web servers, server scripting languages, databases (Apache, PHP, and MySQL), mail servers (Sendmail[6], Horde[7]), firewalls, cache servers (Squid[8]), and network management utilities. In addition to the direct savings for open source over commercial software, there is an implicit savings in hardware. Linux can run on older, less powerful servers than Windows. Consequently, schools are able to set up multiple Linux servers on old machines to

accomplish the same goals that they could meet with fewer, high-power and more expensive, newer servers. In some instances, schools run Linux machines in a computer lab for teaching programming while the rest of the school uses Windows or MacOS.

Linux Terminal Server[9] [10] allows a lab full of computers to run on thin clients from a central server. This greatly reduces the amount of time spent on installing and maintaining software on student workstations. Thin clients place a smaller processing load on user workstations thereby allowing schools to make use of a variety of older, less powerful computers with a minimum of maintenance headaches.

Hundreds of open source classroom application programs are available free of charge. This list includes desktop applications such as word processing, spreadsheets, graphics, and presentation programs. There are also enterprise level administrative programs for enrollment, managing test scores, and hosting e-learning. Adopting open source applications could save a school thousands of dollars. Some schools prefer to use popular commercial applications, because it better prepares students for the software they will likely encounter in their workplace. Schoolforge[11] provides links and reviews of the most popular programs.

Some open source programs support traditional classrooms. MyEDesk[12] is a digital drop box and virtual drive for posting and distributing course documents to students, parents, and teachers. UTIPs[13] is a test item pool server with a library of 10,000 test questions. Learning Content Management Systems (LCMS) provide all the tools to develop and publish electronic courses. .LRN[14] is a course and research collaboration tool that has become popular in higher education. It is built on the OpenACS[15] platform. Open source LCMS's for education are becoming widely available. Often these are associated with courses and content that is also freely available. MyClassroom[16] offered by Visionlearning.org provides a library of learning modules and also a course authoring system. OpenCourse[17] is a Web-based online course content management system that focuses on sharing of Reuseable Learning Objects (RLOs). Interact[18] is an online learning and collaboration platform developed by the Christchurch College of Education, New Zealand. It is a free alternative to commercial programs such as WebCT[19] and Blackboard[20]. Atutor[21] is another full-featured LCMS from Canada. Moodle[22] is a complete online course management system that offers most of the features that commercial learning systems offer such as assignments, forums, chats, online journaling, and quizzes.

There is a rapidly growing system of content libraries supported by state, federal, and private organizations. Examples include The National Science Digital Library (NSDL)[23] sponsored by the NSF, the Digital Library for Earth Science Education (DLESE)[24], and the Eisenhower National Clearinghouse Digital Library (ENCDL)[25]. These libraries serve as portals to large collections of free text, photos, and data.

CASE STUDY: **PLANO ISD**

Plano ISD needed to replace its aging information systems for student, HR, and finance. Commercial software solutions were inefficient to scale and the customizations required to meet local, state, and federal reporting were very expensive. Open standards combined with free open source libraries made it possible for Plano to build their own customized information system. The Java based system enables the flow of information stored in a variety of databases with applications such as textbook inventory systems, master schedules and parent self-pay portals. Plano ISD discovered that custom information systems development is cost effective, scalable, and the results are perfectly tuned to the needs of its users.

The open source movement has stimulated developers to think about how to coordinate their efforts for the greatest good. Sharing costs for development of shared source libraries or sharing course content or reusable learning objects makes good business sense. There is a myriad of options for both open source and proprietary software for schools. Whatever the source, software systems have to be smoothly integrated with each other and with existing systems. There is a need to make it easier to exchange data between applications from different vendors. The idea of developing standards for data exchange has profound implications for educational technology in schools.

WHEN IS COMPATIBILITY BETWEEN APPLICATIONS CRITICAL?

A systems integrator makes sure that all the software applications, networks and hardware work together to the degree they need to. Some applications are completely stand-alone and only need to be able to run on the given network. For example, an electronic book delivered from a CD-ROM has little need to exchange data with other applications. Productivity applications for graphics, word processing, or spreadsheets can work independently, but they often need to read and write a wide range of file formats to work with other applications from other vendors. Database-enabled programs for student records, school purchasing or instructional management have a much greater need to exchange data from various component applications. It is far more efficient to open the classroom electronic grade book and have student names and other pertinent data filled in from the registrar's office, than to manually load a file from a floppy disc or re-enter this data. This is the essence of "interoperability", the ability of applications to exchange data with each other to create a powerful, distributed system.

OPEN STANDARDS FOR SCHOOL SOFTWARE

Just as open source software provides code modules that follow certain rules for input and output, open standards applications are built with protocols for exchanging information that are agreed upon in advance by a community of developers. Standards often emerge from the *de facto* practices followed by groups of users. For example, the mathematics community developed their own markup language MathML[26] for representing their complex formulas on Web pages. Eventually, informal practices become formal open standards that are codified, administered, and periodically updated by a controlling organization. The Standards Interoperability Framework (SIF)[27] was designed for the K-12 instructional and administration area. IMS[28] standards were designed for the needs of higher education and the Sharable Courseware Object Reference Model (SCORM)[29] was developed with the needs of the industrial training and certification market in mind. Several of these standards make use of the course standards defined by IEEE[30] and the Dublin Core[31]. They are considered "Open" standards, because the specifications developed for data tagging and exchange is publicly available. Standards-compliant applications are able to exchange specific types of information where there is a useful overlap. Accessing existing data can save the time and expense of re-entering data, reduce incorrect or inconsistent (dirty) data, and eliminate wasteful redundancy. Standards-compliant applications allow educators to combine data from various sources and analyze trends to provide optimal learning for all students.

OPEN STANDARDS SYSTEM ARCHITECTURE

The Open Database Connectivity (ODBC) standard allows applications to access data from a variety of data sources such as MS-SQL, MySQL, Oracle or Excel. It is a cross-platform API, designed to work not only on different operating systems with

different programming languages, but also allows the same program to access different data sources either locally or across a network. The general database Structured Query Language can be used with a majority of relational databases. Microsoft distributes its own ODBC driver specifications under the Windows OS. Other manufacturers are responsible for their own ODBC drivers.

An application is set up with a specific ODBC data source including a username and password. Each application that opens an ODBC data source expects to find tables with pre-specified yet arbitrary field names and data contents. These data names and formats can be unique for each vendor and are not automatically interoperable. Open standards applications not only have specific protocols for getting connected, they should have extensive predefined "vocabularies" that dictate what different types of information should be called.

Open standards-compliant applications may talk to each other directly or by way of a message broker like the Zone Integration Server (ZIS) defined in the SIF specifications. Direct communication between two applications entails a computer recognizing which application owns or has rights to make changes to which data elements and which applications have permission to request which data elements. Following this, applications can begin to exchange the various kinds of information that is relevant to each. Direct Communication schema tends to be more efficient and scalable. On the other hand, SIF-certified applications operate an "Agent", which is a daemon or background routine that runs continually, ready to receive and send messages to the Zone Integration Server. The ZIS routes and transfers data from applications provided by dozens of different vendors without going through the field mapping of setting up a communication link with each.

Open standards support the exchange of data between multiple applications. For example, an attendance program stores the student record for each day in a database. Each morning the automated telephone message system requests a list of absent students. The attendance program authenticates the request and sends back an XML stream with the names of tardy students. The telephone system then calls the parents of the absent students. The telephone system, attendance system, and student information system could theoretically come from different vendors.

"Open Standards can free information content from the applications that manipulate it."

In a more sophisticated application, the same attendance data sets could be combined with other achievement data to reveal patterns that were formerly hidden. Open standards make the entire web of school information available to inform instructional improvement.

NITTY GRITTY XML- IT'S IN THE TAGS

Most of the open standards are built on an underlying format of Extensible Markup Language (XML). A relative of HTML, XML allows an unlimited number of specialized tags to surround and identify an element of information. The HTML tags in "Important News" tell any Web browser that the words "Important News" should be displayed in bold font. The XML tags "<AttendanceType>Absent</AttendenceType>" tell a student information system that the information within the tags is the attendance status for a given student on a given day. The standards can further specify acceptable values for that data, such as the terms Absent, Tardy, EarlyDeparture, Partial, Present, or Other. Each standards community creates tags and data values that are relevant for its environment. Most of these standards

share common core standards such as the "Dublin Core" which specifies how to tag universal data elements such as creator, date, and language. XML is the emerging *lingua franca* for data exchange between applications and has not typically been the native format for storing the data within an application.

WHICH STANDARDS SHOULD CONCERN YOU?

Selecting standards-compliant software could be extremely important to your school now and in the future. As your information system grows in complexity, the management overhead of supporting many disparate applications may become staggering. Which Open Standard is going to be most important for your school? Which one is supported today by vendors that are relevant to your situation? Which one is likely to be most relevant in the future? Will one standard win the standards race and subsume the others? The answer to these questions comes from understanding your needs, doing your research, and working with vendors who are able to provide a total open solution.

CONCLUSION

Open source and open standards encourage schools, end users, and industry leaders to be directly involved in creating a consensus about what features and conventions should be used in their particular environment. Customers can pick one or more standards-compliant applications and know that they will all work together without a lot of customization. Since the applications are technically interchangeable the vendors must find other ways to differentiate themselves from their competition including providing the best product and paying close attention to customer satisfaction. Customers can mix and match proprietary software with open source components or satellite applications. The ability to share data between applications eliminates redundant data entry and increases security and privacy, because sensitive files can be concentrated in a few, well-protected data warehouses (databases). Open standards provide a basis for the future convergence of school computing environments. While each institution is in a different stage of technology integration, it is prudent to look down the road to see how today's purchases can participate in tomorrow's connected world. Standardized data exchange is critical for achieving the goal of creating efficient, effective use of data and school IT resources, utilizing data where it's needed and providing information that ultimately supports student learning.

REFERENCES

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[3] **Novell Suse Linux** - Novell's adaptation of Linux. http://www.novell.com/linux/suse/

[4] **MySQL** - A full-featured open source database application. http://www.mysql.com/

[5] **PHP** - Personal Home Pages, a popular open source server side web programming language that is an alternative to the Microsoft ASP.Net platform. http://www.php.net/

[6] **Sendmail** - A popular open source mail program. http://www.sendmail.org/

[7] **HORDE** - The Horde Framework is a set of coding standards, common code, and inter-application communication. The shared code provides common ways of handling things like preferences, permissions, browser detection, user help, and more. There is a library of open source applications built on this platform. http://www.horde.org/

[8] **Squid** - A full-featured open-source Web proxy cache that improves Internet bandwidth by automatically caching frequently accessed Internet resources locally. http://www.squid-cache.org/

[9] **K-12 Linux Terminal Server** A thin client server that is customized for the education setting. http://k12os.org/

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[12] **MyEdesk** - A drop box and virtual hard drive for course support. http://www.myedesk.org/refdesk.aspx

[13] **UTIPs** - Utah Department of Education test item bank. http://www.utips.org/

[14] **.LRN** - An open source software for supporting learning and research communities in higher education, K-12, and executive education. Comprising capabilities across several major functional categories and featuring a proven, enterprise-class technical architecture, .LRN is used by over a quarter million users at more than eighteen of the world's leading universities, including the MIT Sloan School of Management where .LRN got its start. http://dotlrn.org/

[15] **OpenACS** - Open Architecture Community System is a toolkit for building scalable, community-oriented Web applications. http://openacs.org/

[16] **MyClassroom** - A learning space where educators and students come together in personalized online classrooms. MyClassrooms for teachers feature customized learning modules, as well as scheduling, communication, and assessment tools. MyClassrooms for students feature course readings and information, calendars, and note tools. http://www.visionlearning.com/library/myclassrooms.php

[17] **OpenCourse** - A collaboration of teachers, researchers, and students with the common purpose of developing open, reusable learning assets (e.g. animations, simulations, models, case studies, etc.). www.opencourse.org

[18] **Interact** - An online learning and collaboration platform developed by the Christchurch College of Education, New Zealand. It is a free, open source CMS, LMS designed to help students and lecturers interact online. It is based on constructivist and vygotskian views of teaching and learning. http://www.interactlms.org/

[19] **WebCT** - This leading commercial provider of e-learning systems for higher education institutions provides a highly flexible e-learning environment that empowers institutions across the educational spectrum with the ability to achieve their unique objectives. Thousands of institutions in more than 70 countries are using WebCT. http://www.webct.com/

[20] **Blackboard** - A popular commercial e-learning product with a complete set of systems that support courses, content, community, campus life, and commerce. http://www.blackboard.com/

[21] **ATutor** - An open source Web-based Learning Content Management System (LCMS) designed with accessibility and adaptability in mind. Administrators can install or update ATutor in minutes, and create themes to give ATutor a custom look and feel. Educators can quickly assemble, package, and redistribute Web-based instructional materials; easily retrieve and import prepackaged content; and conduct their courses online. Students learn in an adaptive learning environment. http://www.atutor.ca/

[22] **Moodle** - A PHP-based course management system (CMS) designed to help educators create quality online courses. One of the main advantages of Moodle over other systems is a strong grounding in social constructionist pedagogy. http://www.moodle.org/

[23] **National Science Digital Library (NSDL)** - A digital library of exemplary resource collections and services, organized in support of science education at all levels. Starting with a partnership of NSDL-funded projects, NSDL is emerging as a center of innovation in digital libraries as applied to education, and a community center for groups focused on digital-library-enabled science education. http://nsdl.org/

[24] **Digital Library for Earth Science Education (DLESE)** - A distributed community effort involving educators, students, and scientists working together to improve the quality, quantity, and efficiency of teaching and learning about the Earth system at all levels. DLESE supports Earth system science education by providing access to high-quality collections of educational resources and Earth data sets and imagery; support services to help educators and learners effectively create, use, and share educational resources; communication networks to facilitate interactions and collaborations across all dimensions of Earth system education. http://www.dlese.org/dds/index.jsp

[25] **Eisenhower National Clearinghouse Digital Library ENCDL** This portal provides users with the ability to search individual ENC collections or across multiple ENC collections, including ENC Online, FEDRL, ICON, GSDL, and the Learning Matrix. Each of these collections has a specific audience; all collections deal with the topics of science, mathematics, and technology. http://encdl.org/

[26] **MathML** - An XML application for describing mathematical notation and capturing both its structure and content. The goal of MathML is to enable mathematics to be served, received, and processed on the Web, just as HTML has enabled this functionality for text. http://www.w3.org/Math/

[27] **The Standards Interoperability Framework (SIF)** - A non-profit membership organization comprised of over 100 software vendors, school districts, state departments of education, and other organizations active in primary and secondary (K-12) education, who have come together to create a set of rules and definitions to enable software programs from different companies to share information. There are more than 50 products on the market that adhere to the SIF Standards. Those that have passed the SIF organization approval process, which is administered by a third

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party (The Open Group), can advertise that their application is SIF Certified. They require an intermediary switchboard and a Zone Integration Server (ZIS), which provides for message transfer, validation, security and queuing. SIF-compliant applications such as a Student Information System (SIS), grade book database, a school lunch manager, testing software, and transportation software can be registered and data permissions defined within the ZIS. http://www.sifinfo.org

[28] **IMS Instructional Management Systems (old name)** - IMS originated in 1997 as a project of Educause and its National Learning Infrastructure Initiative. Its initial focus was higher education, but it is attempting to address other learning contexts such as K-12, corporate, and government training. The IMS provides a set of metadata primarily focused on content, student profile and performance, and course structure. The standard provides interoperability between learning management systems. Currently, there are no IMS compliant products per se as there is no compliance testing and certification program, but there are many member organizations that have committed to developing compliant products, and a certification program is being designed. IMS supports sequencing of learning activities, question and test interoperability QTI, educational objective specifications, and Resource List Interoperability (RLI). http://www.imsproject.org/

[29] **Sharable Courseware Object Reference Model (SCORM)** - The Department of Defense (DoD) established the Advanced Distributed Learning (ADL) initiative in 1997 to develop a DoD-wide strategy for using learning and information technologies to modernize education and training and to promote cooperation between government, academia, and business to develop e-learning standardization. The ADL initiative has defined high-level requirements ("-ilities") for learning content, such as content reusability, accessibility, durability and interoperability to leverage existing practices, promote the use of technology-based learning and provide a sound economic basis for investment. SCORM, like other standards, assumes that there are software applications that deliver learning objects in a sequence, track student progress, branch according to appropriate materials, and then report out student mastery. The standard provides protocols so that applications can work together. The Content Aggregation Model (CAM) is a dictionary of tags, which describe learning contents. The CAM also provides a method of packaging all the learning objects, metadata, and delivery information with an XML "manifest". A learning management system (LMS) is able to read this manifest and recreate the learning experience that the designer intended. SCORM also includes an Application Program Interface (API) for communicating with the LMS. SCORM developers are currently improving the ability of the standard to control sequencing and branching that will enable increasingly complex learning experiences. http://www.adlnet.org/

[30] **IEEE Learning Technology Standards Committee (LTSC)** The IEEE Learning Technology Standards Committee (LTSC) is chartered by the IEEE Computer Society Standards Activity Board to develop accredited technical standards, recommended practices, and guides for learning technology. The Learning Object Metadata standards focus on the minimal set of attributes needed to allow these Learning Objects to be managed, located, and evaluated. The standards will accommodate the ability for locally extending the basic fields and entity types, and the fields can have a status of obligatory (must be present) or optional (maybe absent). Relevant attributes of Learning Objects to be described include type of object, author, owner, terms of distribution, and format. Where applicable, Learning Object Metadata may also include pedagogical attributes such as teaching or interaction style, grade level, mastery level, and prerequisites. http://ltsc.ieee.org/index.html

[31] **The Dublin Core Metadata Initiative (DCMI)** - An organization dedicated to promoting the widespread adoption of interoperable metadata standards and developing specialized metadata vocabularies for describing resources that enable more intelligent information discovery systems. The Dublin Core Metadata Initiative is an open, international, consensus-driven association of metadata practitioners, motivated by the desire to make it easier for people to find information resources using the Internet. http://dublincore.org/

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