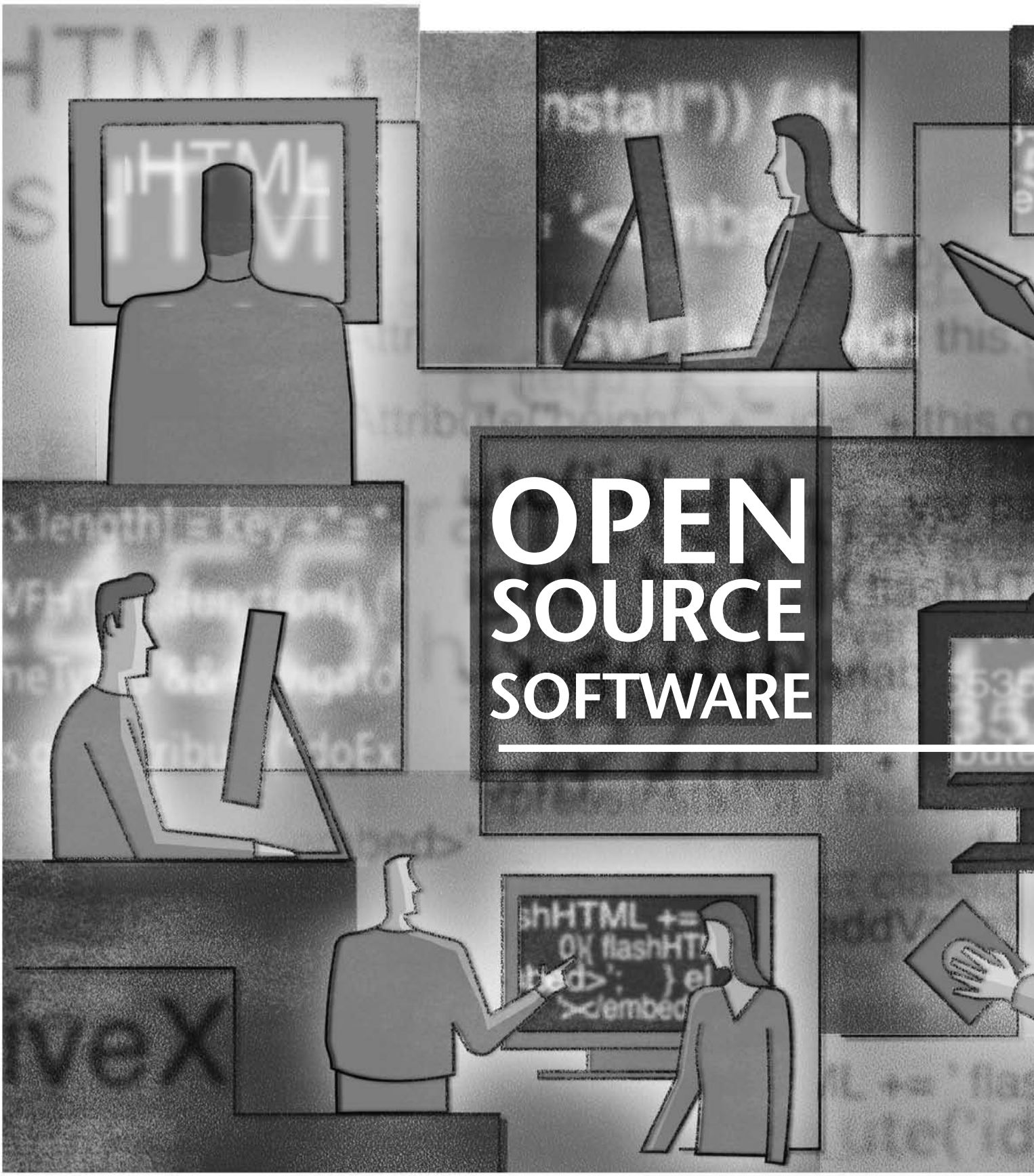
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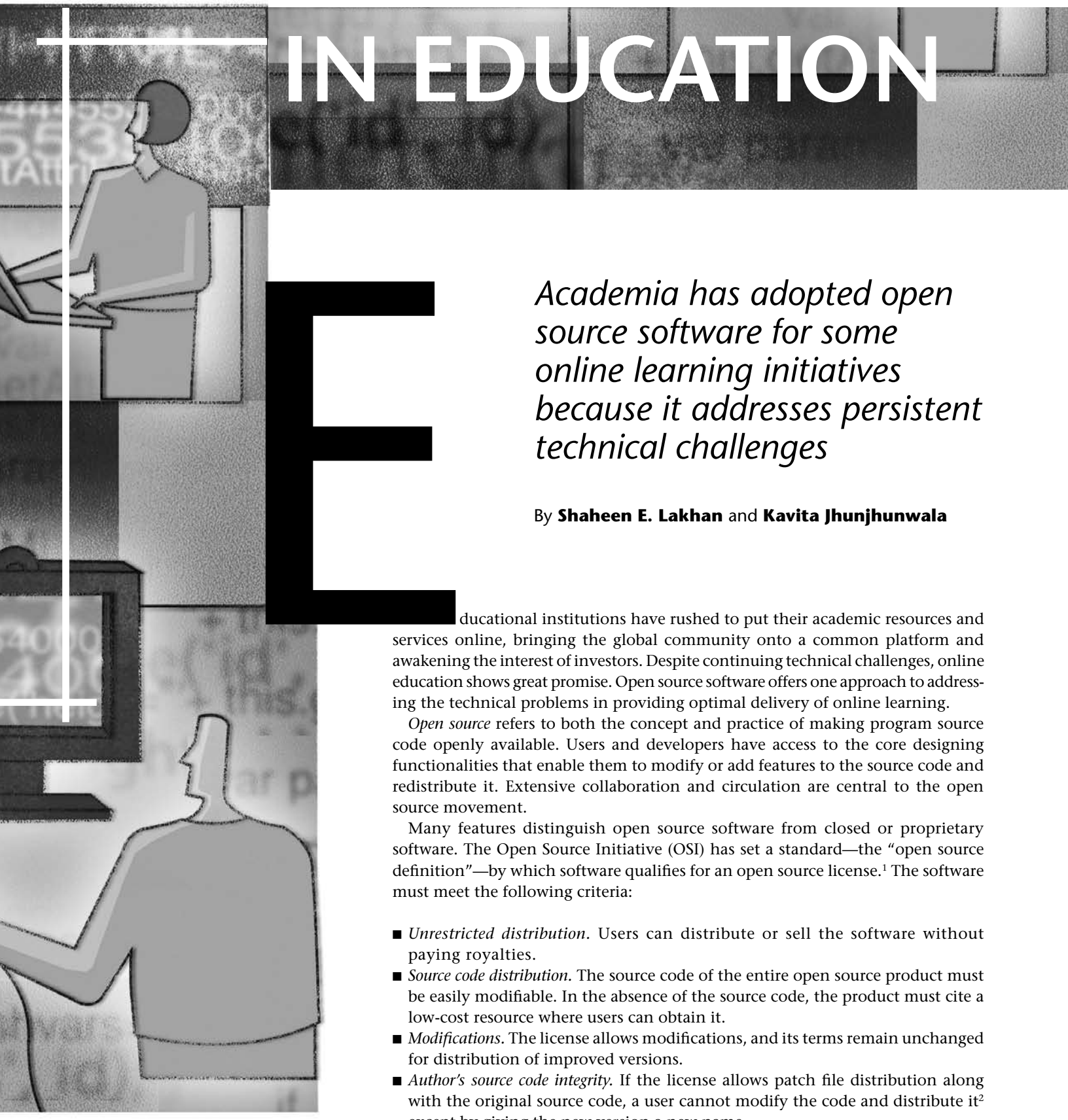


IN EDUCATION

Academia has adopted open source software for some online learning initiatives because it addresses persistent technical challenges

By **Shaheen E. Lakhan** and **Kavita Jhunjhunwala**

Educational institutions have rushed to put their academic resources and services online, bringing the global community onto a common platform and awakening the interest of investors. Despite continuing technical challenges, online education shows great promise. Open source software offers one approach to addressing the technical problems in providing optimal delivery of online learning.

Open source refers to both the concept and practice of making program source code openly available. Users and developers have access to the core designing functionalities that enable them to modify or add features to the source code and redistribute it. Extensive collaboration and circulation are central to the open source movement.

Many features distinguish open source software from closed or proprietary software. The Open Source Initiative (OSI) has set a standard—the "open source definition"—by which software qualifies for an open source license.[1] The software must meet the following criteria:

- *Unrestricted distribution*. Users can distribute or sell the software without paying royalties.
- *Source code distribution.* The source code of the entire open source product must be easily modifiable. In the absence of the source code, the product must cite a low-cost resource where users can obtain it.
- *Modifications*. The license allows modifications, and its terms remain unchanged for distribution of improved versions.
- *Author's source code integrity.* If the license allows patch file distribution along with the original source code, a user cannot modify the code and distribute it[2] except by giving the new version a new name.

- *No personal discrimination.* No person or group shall be discriminated against during open source product distribution.
- *No restriction on application.* Open source software can be used in any field and for any purpose.
- *License distribution.* The privileges attached to the original program extend to all who receive the program, so recipients do not need to apply for a separate license.
- *License must not be product-specific.* The rights associated with a license extend to products extracted from a larger software aggregate.
- *No restriction on other software.* No restrictions are allowed on distribution of open source products bundled with products developed on other software platforms.
- *Technology neutrality.* Licenses should not be issued on the basis of the specific technology involved.

History of Open Source

The development of three operating systems—UNIX, GNU, and Linux—formed the foundation of the open source movement.[3] From its inception, open source has been closely associated with academia.

UNIX had its roots in the joint venture launched in the late 1960s by Bell Labs and MIT to create a new operating system named Multics. Based on that work, some of the programmers developed a new operating system, which they named UNIX, to provide more flexibility to users. Academic institutions could purchase UNIX source codes at a price considerably lower than that paid by corporations and government agencies.

In 1975, Ken Thompson joined the University of California, Berkeley, along with two other graduate students, Bill Joy and Chuck Haley. In 1977 the trio began distributing an open source version of UNIX called BSD. The following year saw the release of a revised edition called 2BSD.

The MIT Artificial Intelligence Lab launched a similar endeavor in which the code was enhanced by passing it among the programmers. The venture lost momentum in the face of advances in computer science.

Programmer Richard Stallman founded the GNU Project in 1984. The GNU General Public License allows users to modify the code and distribute the improved version under the same license. The GNU operating system lacked a kernel, however, until Linus Torvalds developed the Linux kernel. In 1992, the Linux kernel was integrated within the GNU operating system.

Linux became more sophisticated over time with the help of programmers who worked to improve the kernel and create Linux-adapted software. The following years witnessed the introduction of many commercial and enhanced versions of the Linux operating system by vendors such as Red Hat, Mandriva, and Novell. Linux is still available as free open source software.

Learning and Digitization

The digitization of education is a relatively new phenomenon that has transformed the education sector. Corporations and academic institutions have joined forces to further explore the potential for digitizing education through

- Virtual universities
- Online courses
- Education portals
- Courseware

Virtual universities are the best-known form of online education. Accredited virtual universities such as the University of Phoenix offer degrees in mainly professional courses taught largely by part-time faculty members from different universities. Online consortia of academic institutions integrate related courses into programs delivered via a single virtual university.

Online courses are offered in a variety of forms by various sources. Some courses are offered by subsidiaries of renowned traditional universities, although many such courses are not accredited. The parent universities' names act as a powerful draw for online students. Courses are also offered by organizations that create digital collections of study material culled from different academic sources.

Education portals, although not directly connected to the curriculum, have become an integral part of education. Since the late 1990s, some U.S. universities have outsourced e-mail and other Web services, site administrative functions, courseware, and other computer administrative services to software development and application companies.

Courseware is used in both the academic and corporate sectors, with development often outsourced to companies that provide study material for both online and offline purposes. Many companies use sophisticated computerized courses in their employee training programs.

The Internet offers opportunities to combine educational and economic goals on a common, globally accessible platform. This requires extensive technical support to create and sustain the software infrastructure on which digital education primarily depends. Most universities rely on software vendors to support, for instance, virtual learning environments and learning management systems that deliver online learning components. This puts considerable strain on their already overburdened finances.

Following a period of intense competition, the higher education software domain is dominated by a few major vendors,[4] with the risk of monopolization in the future.[5] This leaves academic institutions with one obvious option: to develop in-house systems to fulfill their IT requirements. Unfortunately, such projects often are isolated endeavors riddled with flaws or prohibitively expensive—or both.

Another option is to adopt the collaborative model of open source software development, which enables educational institutions to pool their financial and technical resources. In addition, a huge user community provides a variety of testing environments for the new software.

Open source software products tend to be more reliable and benefit from continuous development. This is one

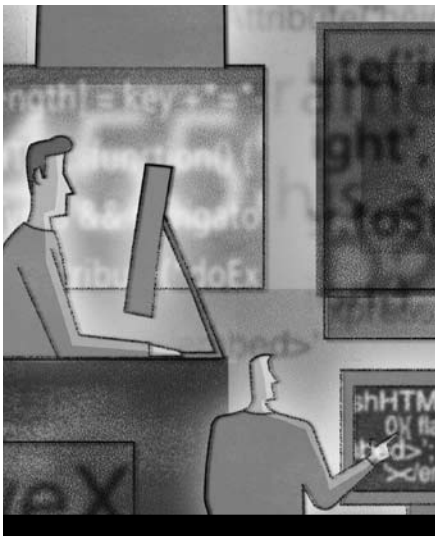
reason to invest liberally in developing open source application software—to work out a more cost-effective way of meeting e-learning software challenges.

Open Source and Its Impact on Learning

As college administrators strive to strike a balance between resources and requirements, open source e-learning software has emerged as a viable solution. Many universities have opted for open source learning management systems, in particular. Advantages that have tipped the balance toward open source include the following:

- *The absence of a license fee.* Most universities annually pay large sums to software companies to use their products, but open source licenses are free.
- *Flexibility.* Open source products are customizable and can involve third parties. New features and tools can be imported from the open source community.
- *Service continuity.* The huge collaborative network of the open source community minimizes, although it does not eliminate, the risk of discontinued service. Volunteer help is available through open source support systems such as forums.
- *Continuous improvement.* Extensive collaboration ensures that software products keep improving. Programmers from different institutions and organizations, along with volunteers, contribute freely to projects.
- *Tax benefits.* Governments of many countries have implemented tax-exemption policies to boost open source projects, although the governmental role in promoting open source software is controversial.[6]

The main potential drawback of open source projects for education becomes evident during their implementation. Using the software to its full potential may prove challenging for beginners, and the availability of the source code is irrelevant for end users if they do not find the product useful. Also, open source



The huge collaborative network of the open source community minimizes, although it does not eliminate, the risk of discontinued service

products are not always compatible with existing software components.

Open source development has other potential disadvantages. There are no guarantees that a project will reach completion and deliver the desired results, for example. Progress depends on the interest and time of the collaborative workforce, and lack of resources or funding can derail a project. Most commercial open source products, however, are self-sufficient.[7]

Intellectual property rights can make it difficult to ascertain whether a particular software solution has been patented. If a process used in an open source project has already been patented, the group can be charged with patent infringement. Although the availability of source code makes it difficult for patent holders to prove infringement, these issues often cloud development of open source software.

Perhaps the most alarming factor to consider is possible loss of support. Typical users are not interested in the availability of source code; they are more concerned with the software's usability. This is one reason proprietary software companies commit resources to product documentation and customer support. The lack of commercial incentives in many open source projects undoubtedly reduces some contributors' enthusiasm. If the support system disappears, educational institutions will have trouble improving and customizing their open source products in the absence of governmental grants or advocacy policies (which are controversial in themselves).

Considering the Options

Educational institutions must consider multiple issues before making a choice among software options. Many nonprofit organizations provide information about open source products and their applicability. OSS Watch, an advisory committee funded by the Joint Information Systems Committee (JISC), provides comprehensive analyses of the legal, technical, and economic aspects of open source software implementation in the higher education sector,[8] and workshops and conferences are organized to help gauge the impact of open source products within educational institutions.

Open educational resources (OERs) are online resources that provide free applications and learning materials for academic institutions.[9] The term, which was coined in a forum on the impact of open coursework for higher education in developing countries, refers to free learning resources including complete course materials, modules, journals, reference materials, and tools that enable users to create online learning management systems and design and publish materials. These resources can be modified and redistributed.

A similar endeavor called open source curriculum (OSC) follows the open source philosophy of making source material accessible to students, instructors, administrators, parents, and governing bodies. Specific instructional goals are set, and designers, content experts, and technical advisors work together to create a complete curriculum. All users can contribute. An open exchange of ideas has enabled these

online open source curricula to reach world-class standards.

Open source resources are available from the following initiatives:

- *Curriki*, the Global Education and Learning Community, is a nonprofit body dedicated to the creation of free, open source curricula for all users and one of the most popular OSC online resources.[10] Curriki provides course materials for primary and secondary education, primarily focusing on the creation of complete curricula for courses distributed and used globally.
- *Connexions* is a pioneering venture[11] set apart from other open-education resources by its scope. The site provides instructional material for primary, secondary, and postsecondary levels, as well as the industrial sector. Contributions are invited from all segments of society. The materials are available in different languages, and users from all over the world can download, customize, and reload them. Authors get credit for their contributions.
- *MIT OpenCourseWare* makes undergraduate and graduate course materials from MIT available on the Internet.[12] This initiative has not damaged the university's reputation but instead has encouraged other institutions to publish their courses online as well.

Open Source Learning Management System Tools

Another aspect of the impact of the open source movement on education is the rapid proliferation of open source learning management system (LMS) tools and other learning applications. LMS tools are used mostly to create and manage learning content on the web. Some of the most widely used LMS tools are briefly described in Table 1 and summarized next.

Moodle. Moodle integrates pedagogical features missing in many LMS tools, allowing instructors to construct customizable, online courses or a wide range of course modules on a flexible platform. Moodle can be downloaded to any computer and used to support a single instructor site or a system of thousands of students. It is licensed by the Open Source Initiative under a general public license (GPL).

Many plug-ins are available to enhance existing features. MySQL and PostgreSQL databases can be used with Moodle, and developers are working to make the system compatible with Oracle, Microsoft SQL Servers, and other databases.

Moodle emphasizes making students a contributing factor in learning; its features invite active participation from students. A growing community of over 200,000 registered users in more than 175 countries supports Moodle. In numerous forums and other interactive centers, developers from all over the world contribute to the software's overall development.

Bodington. This Java-based virtual learning environment was developed by the University of Leeds in the United Kingdom. Bodington aims to provide a flexible, durable learning environment for large, complex institutions with numerous departments. It allows quick upload and management of learning content, and the multilayered administrative model effectively meets varied administrative challenges.

Bodington conforms to World Wide Web Consortium (W3C) recommendations. It also complies with the Special Education Needs and Disability Act 2001,[13] allowing people with physical and visual impairments people to take part in digital courses supported by the Bodington VLE.

A huge community supports Bodington, continually contributing to the software's sophistication. Some Bodington projects have received JISC funding.

Bodington has been implemented at academic institutions including the University of Leeds and the University of Oxford, along with further education colleges. (Further education in the U.K. refers to education received after secondary school, similar to community colleges in the United States.)

Claroline. Built on free technologies such as PHP and MySQL, Claroline addresses the pedagogical needs of teachers and learners, emphasizing training technologies and well-structured online courses. Claroline developers focus on enhancing existing tools to give both instructors and students a refined learning environment.

Claroline is supported by a huge user and contributor community that continuously enriches the software. The nonprofit Claroline consortium, founded in May 2007, is dedicated to enhancing and promoting the software. It is licensed under the GNU GPL.

Dokeos. Dokeos is a web-based application developed on free technologies such as PHP and MySQL. Designed to facilitate e-learning and course management, it provides a flexible, user-friendly platform to simplify the e-learning process.

Dokeos was developed with the help of global contributions made by universities, organizations, and individual programmers. It integrates open source ideas, especially those highlighted in "The Cathedral and the Bazaar."[14] The Dokeos forum facilitates the exchange of ideas among programmers worldwide, with development details available on the Internet. Contributors may send their revised codes via e-mail, wikis, or forums. Dokeos is licensed under the GNU GPL.

.LRN. Pronounced "dot learn," .LRN is a popular tool developed at MIT and based on AOLserver and OpenACS. It supports online learning and other interactive digital systems. Originally designed to meet the needs of universities, it was later implemented in schools, organizations, and corporations. Its flexible framework allows easy customization.

.LRN is supported by an expanding user community and the .LRN consortium. The consortium institutions help each other deploy and enhance the software. The consortium also provides quality assurance by certifying software components as .LRN compatible. The software is licensed under the GNU GPL.

Table 1

Open Source LMS Tools

LMS Tool	Compatibility	Usage
Moodle http://www.moodle.org	Linux, UNIX, Windows, Mac OS X, FreeBSD, and any other system that supports PHP	Downloaded about 500 times a day. More than 28,000 registered sites, over a million courses, a learning community of 10 million.
Bodington http://www.bodington.org	Shibboleth, Linux, Microsoft, Mac OS X, or UNIX	Implemented at University of Leeds, UHI Millennium Institute, and University of Oxford. Provides services to 15,000 users with a single server.
Claroline http://www.claroline.net	Microsoft, Linux/GNU, Mac OS X; complies with SCORM and IMS/QTI.	Available in 35 languages and has users in more than 80 countries.
Dokeos http://www.dokeos.com	Supports SCORM import and LDAP. Data can be imported using CSV or XML files.	In 30 languages and more than a thousand organizations. Implemented at Ghent University and Vrije Universiteit Brussel. More than 28,000 users and 3,600 courses.
.LRN http://www.dotlrn.com	LORS Central, Curriculum, LORS Management, .LRN Ecommerce, Project Manager, Page Editor, Staff List, Syllabus, Expense Tracking	Almost half a million users in 18 countries.
ATutor http://www.atutor.ca	Complies with W3C WCAG 1.0 and W3C XHTML 1.0; supports content developed in IMS or SCORM.	More than 17,000 registered installations worldwide.
OLAT http://www.olat.org	Microsoft Windows, Mac OS X, Linux, Solaris, and UNIX. Conforms to SCORM, IMS QTI, and IMS Content Packaging.	Popular within the European higher education community.
Sakai http://www.sakaiproject.org	Complements commercial software like WebCT, Blackboard, ANGEL Learning, and Desire2Learn.	Adopted by many reputable universities worldwide.

ATutor, OLAT, and Sakai. The ATutor learning content management system was developed by the Adaptive Technology Resource Centre at the University of Toronto. Different feature modules are available, as are third-party plug-ins. The creators tout the software's accessibility and adaptability. ATutor is licensed under the GNU GPL.

OLAT (Online Learning and Training) began in 1999 at the University of Zurich, where a team of developers continues to enhance the software. Much of it is written in Java. OLAT is registered under Apache License 2.0.

Sakai, which its developers call a collaboration and learning environment for education, is built and maintained by the Sakai community. The core software consists of generic collaboration tools, with tools designed for specific applications (such as teaching and portfolio tools) available. The Sakai Project is registered under an Educational Community License.

New Face of Open Source: Web 2.0

The term *Web 2.0* encompasses a set of technologies and practices that has redefined the Internet's user interface and radically changed the way people use the Internet.[15] Among the most important Web 2.0 features are social-networking sites, video- and photo-sharing sites, blogs, RSS feeds, tags, podcasts, wikis, and discussion forums. Knowledge transfer has become a two-way process, with users both receiving and contributing information. As a result, information has become a common and accessible commodity, circulated via interactive communities.

Although Web 2.0 technologies are not designed specifically for digital learning, the academic community looks to Web 2.0 for interactive models. The incorporation of Web 2.0 technologies has changed digital education from a medium to a platform, and many believe Web 2.0 technologies will help digital learning evolve into a mainstream concern.

Moving to Student-Centered Learning

Web 2.0 enables students to participate in a many-to-many information-sharing operation. So far, though, e-learning has been one-way content publishing. Stephen O'Hear wrote:

> Like the web itself, the early promise of e-learning—that of empowerment—has not been fully realized. The experience of e-learning for many has been no more than a hand-out published online, coupled with a simple multiple-choice quiz. Hardly inspiring, let alone empowering. But by using these new web services, e-learning has the potential to become far more personal, social, and flexible.[16]

The traditional learning structure—where students take a backseat while content is developed by instructors and then structured and delivered as courses—has undergone a radical change with the adoption of Web 2.0 technologies. Students have become an important component in the development and distribution of learning content. Stephen Downes called this new phenomenon E-Learning 2.0 in his essay on the same topic: "…E-learning is evolving with the World Wide Web as a whole, and it's changing to a degree significant enough to warrant a new name."[17]

According to Geraldine O'Neil and Tim McMahon,

> The changing demographics of the student population and the more consumer/client-centered culture in today's society have provided a climate where the use of student-centered learning is thriving.[18]

With Web 2.0, the concept of student-centered learning has acquired a new dimension. Previously, the greatest critique of student-centered learning was the lack of resources and the isolation of each student from other learners. Web 2.0 has provided a means through which both collective and individual intelligence can be harnessed, while students bond in stronger, redefined ways.

Teachers all over the world encourage their students to get more involved in creating blogs and other interactive web applications to enhance peer communication in and outside the classroom

This dissolution of distinctive parameters is in line with open source or free software, open access, and Creative Commons licensing. As Ian Davis wrote:

> Web 2.0 is an attitude, not a technology. It's about enabling and encouraging participation through open applications and services. By open, we mean technically open with appropriate APIs but also, more importantly, socially open, with rights granted to use the content in new and exciting contexts.[19]

Common Web Tools

The Web 2.0 tools most commonly used in education are blogs and wikis, although podcasting and media-sharing sites are becoming more common. Teachers all over the world encourage their students to get more involved in creating blogs and other interactive web applications to enhance peer communication in and outside the classroom.

Blogs are the most extensively used Web 2.0 tools. Open source blogging platforms such as WordPress, LifeType, and Roller allow the free creation of blogs (as do many commercial services). Open online portals permit keeping content and feedback on the same platform. Teachers and students can collect, create, and share their own online knowledge resources.

Wiki technology allows site visitors to edit the site's content, accelerating content generation. The most common example is Wikipedia, the online free encyclopedia. Both closed and open source LMSs incorporate wikis, and much open source wiki software is available, including XWiki, TWiki, SWik, and Trac.

Podcasting has been adopted by many institutions to make content available to students in audio form. Stanford University, for example, joined forces with Apple to develop the podcast-based iTunes University. Other universities have followed, signing up for iTunes U. Some of the content available is freely available to the public, while others are restricted (to students).

Podcasting technologies have encouraged an increase in learner-generated content, enhancing learner participation in digital education. Open source podcasting software such as Audacity and Juice is widely employed by the user community.

Media-sharing sites have emerged as powerful tools for the learning community. Many teachers use still images and video, especially those registered under Creative Commons licenses, for both offline and online courses. Media-sharing sites can also be used to publish student-generated video or photographs, shared with peers and teachers to receive critical feedback. Some photo-sharing sites allow the addition of annotations to an image, facilitating distance learning.

Media-sharing and other social-networking sites such as Elgg, Slashdot,

and AROUNDMe can serve as important interactive learning tools. These social-networking tools were not created exclusively for educational purposes, however, and might contain objectionable materials, raising ethical concerns regarding students' exposure to and use of the sites.

One concern about the extensive use of Web 2.0 applications, especially wikis,[20] is access. Developers can assign content development rights to limited users, and some have done so as Web 2.0 tools slowly gain the sophistication needed to provide much-needed security features. This trend goes against the fundamental Web 2.0 idea of liberating content, however, and rouses objections from many users.

It is highly likely that digital education will depart from current Web 2.0 practices and use Web 2.0 tools in entirely different ways. This movement—making information available to a larger section of the global learning community through the Internet and Web 2.0—has introduced greater democracy in the education system as a whole and is one of the strongest arguments for digitization of education.

Destructuring Education with Open Source

The use of open source has enabled universities to create courses easily available to the global education community. The concept of open access and the proliferation of academic blogs have broken down many barriers in the education sector. Pundits have propounded various theories of digital education in response to these changes.

Many people believe, for example, that digitization of education has loosened the bureaucratic framework of traditional learning. The administrative body is less involved—in the sense that teachers and students are more involved—in the direct conduit of e-learning.

Others believe the role of the digital medium in disintermediation is overemphasized. (In economics the term *disintermediation* refers to the removal of mediators, giving users direct access to products.) The traditional teacher or administrator using digital media now has various roles—as content creator, reviewer, technician, and administrator. These hierarchies can be more confusing and no less stern than those found in traditional education. According to Downes and Mui, "In many sectors intermediaries have proven to be remarkably robust. Long chains are being taken apart, but they are also being put back together in new configurations."[21]

The redefined hierarchy may include components that are not part of the university, such as agents representing corporations with an economic interest in e-learning projects. External agencies could be involved in course development, instructional design, LMS development, LMS hosting, and software support. Outside involvement might not directly affect learners, except in case of course fees. Nevertheless, this cross-linking between various agencies is no less complicated than the traditional educational architecture.

Online learning makes education available to the global community. Students almost everywhere have access to quality education through the Internet. Open access is an initiative to give worldwide access to peer-created and -reviewed journal content. The core idea behind such projects is best embodied in the words of the Budapest Open Access Initiative:

> Accelerate research, enrich education, share the learning of the rich with the poor and the poor with the rich, make this literature as useful as it can be, and lay the foundation for uniting humanity in a common intellectual conversation and quest for knowledge.[22]

A large chunk of digital education is guided by e-commerce goals, however. Some online courses cost as much as on-campus courses, making higher education financially inaccessible to many students. In addition, mass-marketing of education might decrease the brand value of prestigious online courses, undercutting the commercial goals for online education. The university's status is a major factor attracting students and influencing employers in evaluating online degrees.

Nonetheless, the commercial model of education has made education more learner oriented, with courses structured according to what learners need or want. This has led to the decentralization of education. As Chris Werry wrote,

> The Internet is allowing entrepreneurial companies and innovative colleges to unbundle learning and credentialing services from the whole campus-based industry with its high cost of research and residential services and to deliver these services to a growing marketplace. The learning revolution has only just begun to capture the promise of the democratization of knowledge made possible with Internet technologies.[23]

Market demand will foster the emergence of numerous courses and modules not available in the traditional learning framework. This will give rise to a highly flexible learning process, with a greater scope for mass customization.

Conclusion

Open source products have gained considerable currency in the realm of higher education. The question remains, nevertheless: What is the future of open source software in higher education? From a commercial perspective, open source projects are taking their first tentative steps into the marketplace. This might be good news for universities because it would remove the threat of market monopolization, but to measure up to industry standards, open source projects need more sophistication. If collaborative contributions continue at their current pace, this might not be difficult to achieve.

The nature of collaborative contribution could cause some concern. Although the community-based model agrees with the culture and values of higher education, enthusiasm cannot be the sole incentive. Some other form of encouragement is needed to avoid the "forking" of codes,[24] which is modifying the technology of the vendor one

has been working with and developing a new business model around it by rebranding the technology. Forking is a common problem for open source technology companies. Probably only a few large communities with considerable commercial backing will survive after a few years. Projects like Sakai and the Kuali Foundation, which involve both academic and corporate concerns, have more chance of lasting than small, isolated, open source software projects.

Moreover, the development of open source software is largely dependent on the requirements of the e-learning industry, which itself has to endure the test of time. Nearly 20 percent of students who enroll for higher study in the United States opt for e-courses, and the e-learning growth rate exceeds that of the traditional education sector, but the emphasis is more on quantity than quality.[25] Getting qualified instructors could prove difficult, for example. Sometimes existing instructors have to double or even triple their workload to manage online teaching. This can have an adverse effect on the quality of online courses. Also, e-learning has yet to gain the confidence of employers. A study conducted by Vault.com found that around 77 percent of employers prefer online degrees from accredited, established universities.[26] The existence of multiple accreditation agencies (regional, national, and specialized) is a bit confusing, however.[27] Centralized accreditation might more effectively convince prospective employers of the quality of an online program.

Open source and digital education and learning, separately and together, aim to reach everyone. Although both movements have gained considerable maturity, a need for greater coordination exists. A cohesive plan must bring together open source principles and technologies, educational institutions, and economic factors so that each component's role is clearly defined. Both open source and digital education projects are taking their first tentative steps into the consumer world. They have a long way to go before they enter the mainstream, but together they have great potential to change forever the face of education. *e*

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