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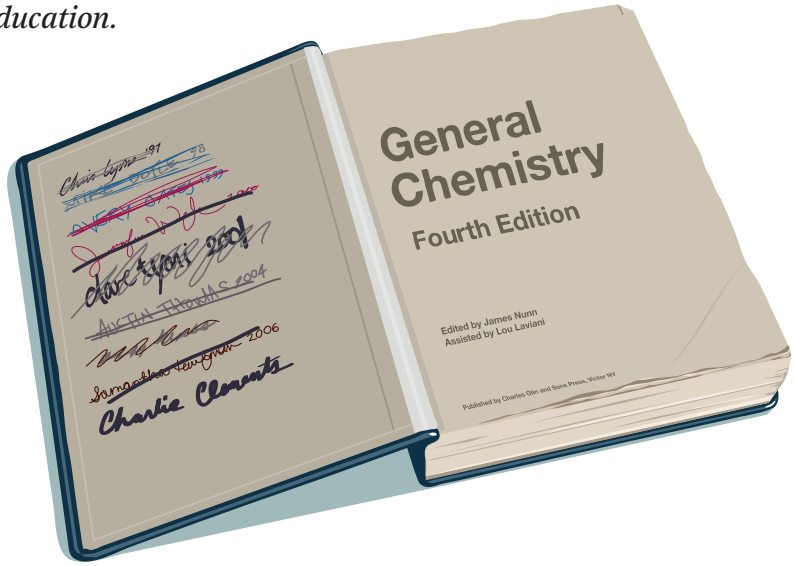
Viewpoint
Global Warming Toward Open Educational Resources

Seeking to realize the potential for significantly improving and advancing the world's standard of education.



THERE IS A looming discontent in the education world. Karen has dropped out of community college because her textbook costs exceeded her tuition bill. Eric, a third grader, must share his math textbook with his classmate because there aren't enough textbooks for all of the students. Juan's parents can't help him with his homework because they don't read English. Kelly, a science teacher, wonders whether Pluto will be reinstated as a planet by the time it is removed from her school's science textbooks. Rashid, a master teacher, is examining some of the 109,263 errors recently found in textbooks under review by the Texas State Board of Education. Patrick, a premedical student, is struggling to understand Newton's laws of motion from the text, formulas, and pictures in his textbook. Carla, an elementary school teacher, must purchase music materials out-of-pocket for her fourth-grade class due to a reduced school budget. And John, a university professor, is astonished to learn that the book he published three years ago is already out of print.

The buzz surrounding the high cost, limited access, static nature, and often low quality of the world's textbooks has reached a crescendo lately, with many claiming a serious threat to the future of the next generation, the training of work forces worldwide, and the democratic process in society. The current predicament lowers the quality of education in the developed world; even worse, it puts education out of reach for many in the developing world.

Imagine another world that has forestalled this crisis. A world where textbooks and other learning materials are free for all on the Web, available in low-cost printed versions, adapted to many backgrounds and learning styles, interactive and immersive, translated into myriad languages, continually up to date and corrected, and never out of print. Imagine virtual labs that can be used any hour of the day (or night). While this world was just a dream a decade ago, the Open Educational Resources (OER) movement that aims to create it has begun to coalesce and gather momentum.

Enter Open Educational Resources

The OER movement is based on a set of intuitions shared by a wide range of academics: knowledge should be free and open to use and reuse; collaboration should be easier, not more difficult; people should receive credit and kudos for contributing to education and research; and concepts and ideas are linked in unusual and surprising ways, not necessarily the simple linear forms that today's textbooks present. OERs promise to fundamentally change the way authors, instructors, and students interact worldwide.[1,3,4]

The OER movement takes the inspiration of the open source software movement, mixes in the powerful communication and visualization abilities of the Internet and the Web, and applies the result to teaching and learning materials like course notes, curricula, labs, and textbooks. OERs include text, images, audio, video, interactive simulations, problems and answers, and games that are free to use and reuse in new ways by

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anyone around the world.

Over the last decade the technical, legal, and social puzzle pieces have come together so that anyone, anywhere can now author, assemble, customize, distribute, have reviewed, and publish their own textbook in very little time and at zero or very low cost. The key enablers are:

▸ Technologies like the Internet, which enables virtually free digital content distribution; XML, which turns a monolithic textbook into a rapidly reconfigurable construction of small, reusable "modules," much as building with Lego blocks; Web 2.0 tools like wikis and semantic tagging systems, which enable real-time distributed global collaboration; advanced visualization and graphics tools, which enable immersive simulation environments; and print-on-demand systems, which enable the production of inexpensive paper books for those who prefer or need them.

▸ Open copyright licenses like the Creative Commons and GNU Free Documentation licenses, which turn once closed and static educational materials into living objects that can be continuously developed, remixed, and maintained by a worldwide community of authors and editors.

Several OER projects are already attracting millions of users per month (as of July 2008). Some, like the MIT OpenCourseWare project (mit.edu/ocw) and its OCW consortium (ocwconsortium.org), are top-down organized institutional repositories that showcase their institutions' curricula. Others, like Connexions (cnx.org), are grassroots organized and encourage contributions from all comers. Still others, like the Open University's OpenLearn project (openlearn.open.ac.uk), combine aspects of both. Wikipedia (wikipedia.org) is regularly referenced by students, teachers, and faculty and is increasingly used directly as a learning tool. A consortium of community colleges throughout California and around the U.S. is developing a suite of free, open textbooks.[2] Governments like Vietnam's are committing to OERs to help reinvent their educational systems (vocw.vn). Professional societies like the IEEE are getting involved as a way to bolster their global educational outreach (ieeecnx.org). And the Student PIRGS Open Textbooks campaign (maketextbooksaffordable.org) is working to raise awareness of both textbook costs and this new avenue to reduce them. As a sign of the maturation of the movement, delegates from around the world met in Cape Town, South Africa to develop the eponymous Declaration that was officially released in January 2008 and has already garnered signatures from more than 1,600 individuals and 165 organizations to date (see capetowndeclaration.org).

Free and Open are Just the Beginning

The most exciting thing about OERs is that free access is just the beginning. OERs will increasingly blur the lines between courses, grade levels, labs, and textbooks, turning the current textbook production pipeline into a vast dynamic knowledge ecosystem that is in a constant state of creation, use, reuse, and improvement. OERs also promise to provide each child with his or her own textbook that's tailored to the student's background and learning style (not "off the rack" as they are today) and to the institution's goals.

OERs enable the development of tighter feedback loops that immerse students in interactive learning environments and couple learning outcomes more directly into textbook development and improvement. A key online ingredient will be "Web 3.0/Semantic Web" technologies based on natural language processing, data mining, machine learning, artificial intelligence, and semantic markup languages like MathML, MusicXML, and CML (Chemical Markup Language). The result will be "textbooks" that not only deliver open content to students but also monitor their interactions with them, analyze those interactions, and then send rich feedback to the student about their learning, as well as to the communities of curriculum builders, authors, and instructors to drive iterative improvement of the learning materials. An early example that currently focuses more on student feedback than continuous iterative content improvement is Carnegie Mellon University's Open Learning Initiative (cmu.edu/oli).

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Free and Open as a Business Model

OERs are not at odds with the for-profit world. Indeed, we contend that the new development and distribution models promoted by the OER movement represent the natural and inevitable evolution of the educational publishing industry in a way that parallels the evolution of the software industry (the now-mainstream Linux, Apache, and Firefox), the music industry (Radiohead's recent "pay what you like" digital album download), and the scholarly publishing industry (the U.S. government's recent mandating of free online access to all journal articles stemming from NIH-funded research). The key enabler in all of these is free Internet-based digital distribution. Chris Anderson, in his *Wired* article "Free: Why $0.00 is the Future of Business," argues that while free was once a marketing gimmick, it is now emerging as a full-fledged economic model.

This economy provides many avenues for financially sustaining myriad different OER projects. Just as for-profit companies like Red Hat, IBM, Oracle, and others charge customers for the value they add to open source software and then in turn give back to the open source community through direct financial support, programming personnel, and free marketing, value-adding for-profit organizations are emerging in the OER space. For example, non-profit Connexions' partnership with for-profit QOOP (qoop.com) enables the production of print-on-demand paper textbooks that sell for a fraction of the price of a conventional commercial publisher ($20 for a 300-page engineering textbook in regular use at Rice University; $29 for a 500-page statistics textbook in use at a number of California community colleges starting in fall 2008). A three-way revenue-sharing arrangement benefits QOOP, Connexions, and the author (if

the author is interested in receiving royalties). And of course the content is also available for free on the Connexions Web site, which will keep the commercial costs from rising above what the value added justifies.

Roadblocks on the Horizon?

While the OER movement is rapidly gaining speed, there are a number of potential roadblocks that must be carefully navigated for it to prosper.

Technology fragmentation. If the OER community does not adopt common or compatible content and repository standards, then it risks fragmenting the movement into a number of isolated islands of incompatible content. This will unfortunately discourage global collaboration, reduce the overall economy of scale of the enterprise, and thus devalue any financial sustaining opportunities. We must pay attention to the lessons learned by groups like the World Wide Web Consortium and its standardization and maintenance of the HTML and XML standards.

Intellectual property fragmentation. Just as with open source software, there are a number of copyright licenses that can be applied to OERs. These various licenses present a number of compatibility issues. For instance, there is currently a debate regarding whether open materials should or should not be commercially usable. Licensing that renders open materials only noncommercially useable promises to protect contributors from potentially unfair commercial exploitation. A noncommercial license, however, not only limits the spread of knowledge by complicating the production of paper books, e-books, CDs and DVDs, but also cuts off potential future revenues that might sustain non-profit OER enterprises in the future. Interestingly, such an anticommercial stance is contrary to that of the more established open source software world, which greatly benefits from commercial involvement. Where would Linux and Apache be without the value-adding contributions of for-profit companies like Red Hat and IBM, for instance?

Quality control. How can OERs produced in a grass-roots fashion, by people with varying skill levels and degrees, for widely varied reasons, be adequately vetted for quality? The anxieties frequently aired about projects like Wikipedia and other open-authorship projects suggest they are threatened by the proliferation of massive amounts of low-quality material that might swamp the information environment and prove impossible to navigate. Traditional publishers, as well as institution-based OER projects like MIT OpenCourseWare, employ a careful internal review process before their content is made publicly available. However, such a prepublication review cannot scale to keep up with the fast pace of community-based OER development, where materials may change daily or even hourly. Accept/reject decisions also create an exclusive rather than inclusive community culture. And finally, prereview does not support evaluation of modules and courses based on actual student learning outcomes. Some promising steps are being made in this direction. In one, Connexions recently rolled out a system of post-publication "lenses" that are open to an arbitrary number of third-party reviewers and editorial bodies. Several universities, companies, and professional societies are currently reviewing content for their lenses (see cnx.org/lenses).[5]

OERs have the potential to aid in the democratization of the world of knowledge.

Success models. While the advantages of remixing and reusing educational content are readily apparent (and while authors already consciously and unconsciously remix ideas from myriad different sources as they compose), we need more OER success models to build upon. We surmise that the lack of a large number of models is due in a large part to technological barriers (which are gradually being overcome) and in a lesser part to several hundred years of academic community dynamics (which are being addressed by community-organized OER projects like the IEEE's mentioned earlier).

Moving Forward

Our experience with OERs over the past eight years has convinced us that the movement has real potential to enable a revolutionary advancement of the world's standard of education at all levels. Moreover, as it grows and spreads, the movement will have a large impact on the academic world itself. It promises to disintermediate the scholarly publishing industry, in the process rendering some current business models unviable and inventing new viable ones. It will also change the way we conceive of and pursue authorship, teaching, peer review, promotion, and tenure. And by encouraging contributions from anyone, anywhere, OERs have the potential to aid in the democratization of the world of knowledge.

A concerted effort from the community of authors, instructors, students, and software developers (that is, by you) will enable the OER movement to surmount the challenges on the road to these goals. Fortunately, it's easy to get involved: become an author for an OER project on your favorite topic; contribute your out-of-print work so others can build on it and keep it alive; adopt or remix an open textbook for your next course; start or participate in an OER quality review program; or translate an OER into a new language. Together, we can change the way the world develops, disseminates, and uses knowledge. C

References

1. Baraniuk, R.G. Challenges and opportunities for the open education movement: A Connexions case study. Chapter in *Opening Up Education: The Collective Advancement of Education through Open Technology, Open Content, and Open Knowledge*, MIT Press, 2008.
2. "'Bookless' textbook study launched at Foothill," Palo Alto Online (May 5, 2008).
3. Breck, J. Editor of the special edition on open education in *Educational Technology* 47 (Nov.–Dec. 2007), 3–5; C. Sidney Burrus, "Connexions: An Open Educational Resource for the 21st Century," 19–23; Stephen Carson, "The OpenCourseWare Model: High-Impact Open Educational Content," 23–26.
4. Kelty, C.M. *Two Bits: The Cultural Significance of Free Software.* Duke University Press, 2008.
5. Kelty, C.M., Burrus, C.S., and Baraniuk, R.G. Peer review anew: Three principles and a case study in postpublication quality assurance. In *Proceedings of the IEEE 96*, 6 (June 2008).

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