Why the ChemWIKI

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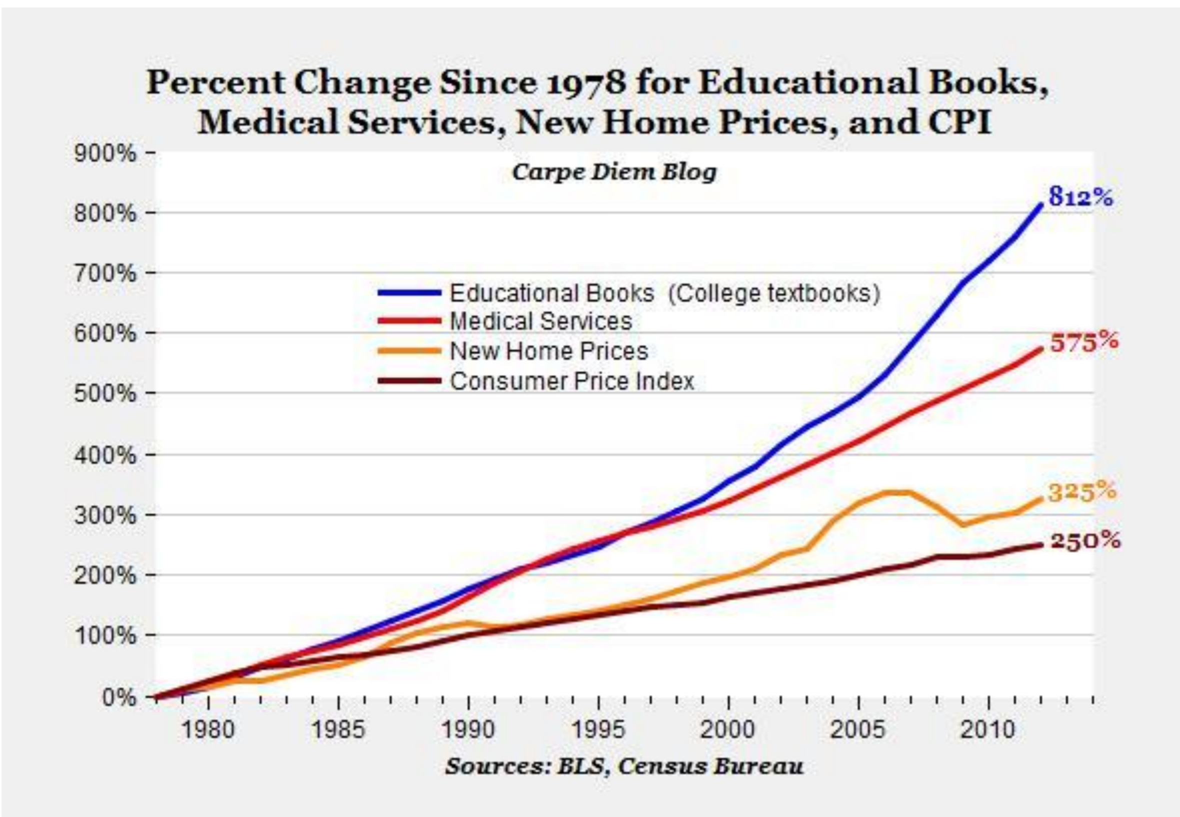
Abstract:

Discussion about textbook price is anchored to cost. Here I argue that cost is a relatively minor issue in the choice of books by instructors but rather ancillary services offered by the publishers dominates. Thus, any attempt to replace published textbooks with open on line educational resources must pay careful attention to providing these. This drives the current transformation of the ChemWIKI into a Stem Hyperlibrary.

The discussion about on-line textbooks revolves around cost, and indeed, this is an important and vexing problem. The costs of textbooks has grown faster than the cost of drugs. As Joseph Weissman at the Atlantic has shown this has indeed become absurd. [*Weissmann*, 2013]



The first part of this essay will describe the roots of dysfunction in the US textbook market and the role of faculty. Students, of course, are increasingly burdened by these costs. Recently, faculty, administrators and even legislators have become more aware of the pressures this is putting on students. Still, the question remains, are no-cost on line textbooks sufficient motivation for faculty to actively participate in creating and using them. That question will be addressed in the second part of the essay in the context of my own experience and the ChemWIKI project. While growing textbook cost was Delmar Larsen's initial impetus for creating the ChemWIKI [*Rusay et al.*, 2011], it is my opinion that cost to students alone is not sufficient motivation for faculty to use open on line educational resources (OOER) in their classes. The third section of this paper will discuss how this will require building out OOERs to become fully capable educational systems, not just online textbooks.

Who ordered that?

If it is a college textbook, the professor. Publishers market their books to faculty, rather than to students who purchase them. In 2005 the GAO issued a report on the costs of textbooks requested by David Wu (R) Representative from Oregon.[*Ashby*, 2005] This report was heavily influenced by the publishers who insisted that the increase in cost was driven by the enhancements that competition forced them to incorporate. Textbooks are marketed and in great part selected based on the services that the publishers offer to faculty including such "traditional" features as publishers representatives, desk copies, solution manuals, test banks and slides and more modern apps including online homework systems.

Interestingly textbook cost is a non-partisan issue in the US. Both right [*Perry*, 2015] and left [*Farrell*, 2015] are considerably dissatisfied with the status quo but neither side goes much beyond the cost issue.

The economics are simple. At a large university the GChem course might have 1000 students or more. At $250 for the book (more if the students are offered the "package") that is $250,000 about 75% of which goes to the publisher and the rest to the bookstore. Of course, this has been less and less the case with the textbook market moving on line. To an extent this explains the changing attitude of administrators as bookstore profits have disappeared. Bookstores have been increasingly outsourced and are now regarded more as services and less as profit centers.

The cost of tuition at community colleges is of the order or $100/credit hour, and the cost of a textbook is $250 for a three credit course. The situation is negatively affecting higher education in the US as students seek to escape economic thrall by not buying books, and selling them back as soon as they can.

There is increasing awareness of the textbook cost problem as an important component in the cost of higher education. The Oregon Higher Education Coordinating Commission for example came up with a list of best practices [*Workgroup*, 2014]

- Alter the tuition and fee formula at OUS schools so that fees include the instructional materials for the course.
- Creation of Open Educational Resource web archive or wiki or portal.
- Create a cost of instructional materials index.

- Review and strengthen existing textbook affordability policies created by OUS and the Board of Higher Education.
- Perform a cost-benefit analysis of the use of library reserves of required texts.
- Explore cost savings from promoting the production of instructional materials, not just textbooks, with both Creative Commons and traditional copyright and licensing rights.
- Negotiate statewide licenses, not for individual textbooks, but for full access to a publisher's library.
- Investigate the possible abuse of "custom editions" by faculty and publishers.

Individual colleges within Oregon are responding to this initiative with their own studies and programs to reduce textbook costs [*Moody et al.*, 2015] as well as at many other universities. [*Waltz*, 2015].

Yet given issues of academic freedom in higher education associated with a faculty member's absolute responsibility for the courses that they teach, OOERs will have to provide significant advantages to faculty beyond cost to be broadly adopted.

My experience

Let's start with teaching, in particular my teaching. Over the years I concluded that the Atoms First approach is superior. Most General Chemistry texts and courses teach an historical sequence of many simple models for chemical bonding and reaction. As each model is stacked on the next to extend them and handle myriad exceptions to each, students struggle. Why each of these simplifications works and their limits of applicability is not obvious, or at least not so until the course reaches the last few weeks when instructors rush through the quantum basis of atomic and molecular structure. At that point, perhaps in the last lectures of the term, when it is explained how each of the historical models is an expression of quantum mechanics, everyone, hopefully, nods their heads and says "Oh yeah".

For a number of reasons, including the unwillingness to reorganize their course, a contract with a publisher to provide a cost break, and issues about timing of teaching stoichiometry and thermochemistry, none of my colleagues were willing to go to an Atoms First book. At first I used the traditional textbook but simply varied the order in which the chapters were taught. This was not very well received. Frankly it confused the students, so I was attracted to the ChemWIKI, where I could with some effort build my own text that students could use without having to invest another $300 if they moved out/into my section at the end of the first semester.

I made two discoveries. First that the medium allowed new and useful messaging using videos, applets and other on line resource. Further, in Henry Pence's frame by inserting links, applets, videos and more, I could, to an extent, control the direction of the student's multi-tooling.

Second, an on line text is never perfect and never done. The aim in the first pass through was to provide a useful text that could be improved. The first chapters I put together, were different than the last, as new bells and whistles were added. Student feedback is also important. For example, in the next rewrite, I will be adding explicit links between the textbook and my lecture notes, which I also distribute.

Another example of the flexibility of the ChemWIKI is a new text that I am writing with colleagues at Prince George's Community College. Many engineering students, EEs, MEs and CEs only take one semester of General Chemistry. This is a problem, because many topics important to engineers are not covered in the first semester, including equilibrium and kinetics

The atoms first text is being rewritten to serve a one semester Chemistry course for Engineers that includes kinetics, equilibria and materials science, nuclear chemistry, etc. Because most general chemistry courses are oriented towards student who are interested in health science careers, supplementary materials are often not very interesting for engineers. Our approach is to strip out of a one semester general chemistry for engineers material that the students will cover elsewhere, and to assume that engineering students are more mathematically sophisticated than the average general chemistry student. This will allow PGCC to cover key subjects not usually taught in the first semester.

This flexibility is inherent to the design of the ChemWIKI and the developing Hyperlibrary. It is a key feature for faculty looking to extend their course "beyond the book".

Beyond Textbooks - The Future

Science is a gift culture where discoveries and help are freely given and those who contribute the most are the most highly valued. A key to establishing high quality OOERs will be extending this ethic to educational resources so the effort of all who participate is rewarded. A perplexing cultural issue is that research intensive universities have more problems with this than non-research habituated ones. The rise of chemical education as a separate area of chemistry has improved this situation, but it will also be important to attract those working and teaching in the traditional chemical divisions to creation of materials, and some systematic rewards, including released time and credit for step raises and promotion should be instituted by departments and schools. This is justified by efforts at controlling student costs locally and on state and federal levels.

The Hyperlibrary of the Future

Delmar Larsen of the University of California Davis started the ChemWIKI project provide open, no cost, on line chemistry textbooks of high quality. Integration of other areas including physics, math, biology, and geology are growing the ChemWIKI into a StemWIKI Hyperlibrary. Currently the ChemWIKI with over 7.5 million page views by over 5.3 million visitors per month is a powerful mechanism for dissemination of content, a new NSF IUSE grant supports development of digital evaluation of the on line material and inclusion of complementary ancillaries that will transform the StemWIKI Hyperlibrary into a complete Open On Line Educational **System.**

Key to this will be the development of a Student Advancement Rating and Inquiry System (SARIS). SARIS will be open-access and can be closely integrated with STEMWiki pages providing formative evaluation of students, teaching methods and the STEMWikis. SARIS is being developed with advanced assessment infrastructure leveraging "big data" applications such as stock market analysis.

SARIS will be forked from the existing Qoll system (http://Qoll.io) that is in the initial stages of testing with Hyperlibrary content. The Intelligent Homework System underlying SARIS departs from existing homework management systems by developing knowledge structures that continually evolve in a Bayesian fashion to fit the progress of individual students, thus supporting diversity in learning styles as well as their pre-existing biases.[*Gelman et al.*, 2004] Bayesian statistics build on the idea that modelers of a real world phenomenon should keep updating their views of the world (i.e., model parameter values change as new information comes in). This idea introduces variables in the model of knowledge structures that will put the student and teachers at the center of the estimation and adaptive feedback methods. Bayesian statistics are formative, [*Neal*, 1995] with each new piece of data used to update the model, while frequentist statistics require enough data to form a distribution against which new data is compared. Thus, Bayesian methods provides usable estimates from relatively smaller data sets.[*Baker and Yacef*, 2009]

Quoll functions as an open-access Bring Your Own Device classroom response system. Instructors will be able to couple the response system to SARIS for in-class individual assessment and have the option of including the in class assessment into the course assessment.

Robert Belford, one of the co-PIs on the IUSE grant is integrating ChemCollective Virtual Laboratory (VL) simulations into the Hyperlibrary where they can be used not only as laboratory exercises, but also as lecture simulations. For graded assignments at the University of Arkansas Little Rock and other participating schools (this will require IRB approval) student will have separate logons that will generate maps of how the students use the VLs resulting in a better understanding of how students learn the material.

With the integration of evaluation and homework systems, a sign on application is needed. The proposed system will feature centralized authentication across all Hyperlibrary applications. While the SARIS features will not be accessible without sign ons, all other features will be universally accessible.

Jason Shorb at Hope College will port ChemPRIME into the ChemWIKI. ChemPRIME was originally developed John Moore at Wisconsin and absorbed by the American Chemical Society, however they have not maintained the site and it has been attacked by spammers. Integration into the Hyperlibrary will revive this pioneering effort and make it available to large numbers of students.

Conclusion

Textbooks are chosen by and marketed to faculty for whom price is not a controlling concern. Open, on-line electronic resources are a promising response but have not really met the challenge of providing ancillary resources for instructors associated with modern texts. This limits market penetration. The migration of the ChemWIKI to a STEM Hyperlibrary will provide an integrated Open On-Line Education System controlled and created by faculty for the benefit of educators and students.

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A Brief (and Probably Unnecessary for Most) Introduction to the ChemWIKI

The ChemWIKI is divided, like Gaul, into three parts. The first, the core http://chemwiki.ucdavis.edu/Development_Details/The_Core, is composed of modules, which either can be organized as texts,
http://chemwiki.ucdavis.edu/Analytical_Chemistry/Analytical_Chemistry_2.0,
or as single subjects,
http://chemwiki.ucdavis.edu/Physical_Chemistry/Physical_Properties_of_Matter/Phases_of_Matter,

These texts can be used free standing or linked together for instruction.

The second is a series of textbook maps (many of the maps are not yet finished). The idea is to present material that matches the content and order of various textbooks. While not identical with a particular textbook these are especially useful in the case where a student cannot afford the textbook. An example would be the map for McQuarrie and Simon, Physical Chemistry

http://chemwiki.ucdavis.edu/Textbook_Maps/Physical_Chemistry_Textbook_Maps/Map%3A_McQuarrie_and_Simon_%22Physical_Chemistry%22

The third part includes teaching material for various courses. These range from complete texts

http://chemwiki.ucdavis.edu/Wikitexts/Purdue/Purdue%3A_Chem_26505

to texts under construction

http://chemwiki.ucdavis.edu/Wikitexts/Hope_College/HOPE_344%3A_Krueger

and textbook maps

http://chemwiki.ucdavis.edu/Wikitexts/Diablo_Valley_College/DVC%3A_Chem_120

The ChemWIKI is growing to cover more areas of science, including biology http://biowiki.ucdavis.edu/ geology http://geowiki.ucdavis.edu/ statistics http://statwiki.ucdavis.edu/ physics http://physwiki.ucdavis.edu/ and math http://mathwiki.ucdavis.edu/ .

Individual modules in these daughter wikis may be interesting to chemistry students, for example the section on biochemistry in the biowiki http://biowiki.ucdavis.edu/Biochemistry