

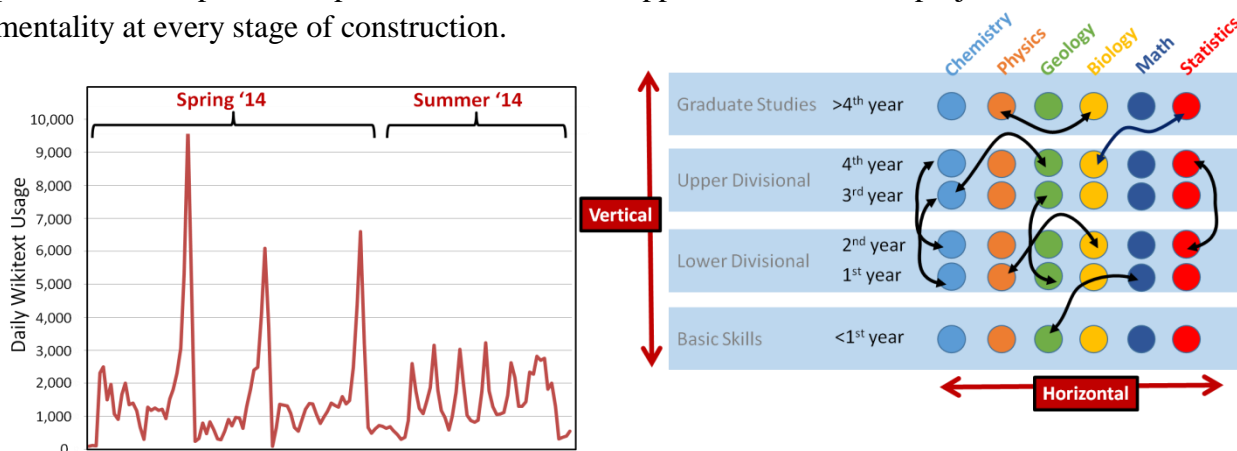
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**Title:** The ChemWiki: A Free Online Substitute for Commercial Chemistry Textbooks

**Abstract:** The ChemWiki (<http://ChemWiki.ucdavis.edu>) is the largest component of the UC Davis (UCD) STEMWiki Hyperlibrary with six other pseudo-independently operating and interconnected “STEMWikis.” The ChemWiki focuses on augmenting post-secondary chemistry education with the primary goal of developing and disseminating viable online textbook alternatives within a central environment that is both vertically (from advance to basic level) and horizontally (across different fields) integrated and provides students with high quality cost-free textbooks. The project is developed by a consortium of students and faculty across multiple campuses and countries and grows monthly.

### Brief Description of the ChemWiki

The ChemWiki is the primary and most developed component in the University of California, Davis Hyperlibrary project with six other pseudo-independently operating and interconnected “STEMWikis” that focus on developing and disseminating viable online post-secondary textbook alternatives within a central integrated environment. The Hyperlibrary is a “crowd-sourced” project that is developed by a consortium of students and faculty across multiple campuses and countries. Development entails collecting, integrating, vetting, and building open-access content within a unified and hyperlinked infrastructure. This practitioner-developed, practitioner-adopted, and practitioner-evaluated approach infuses the project with an end-user mentality at every stage of construction.



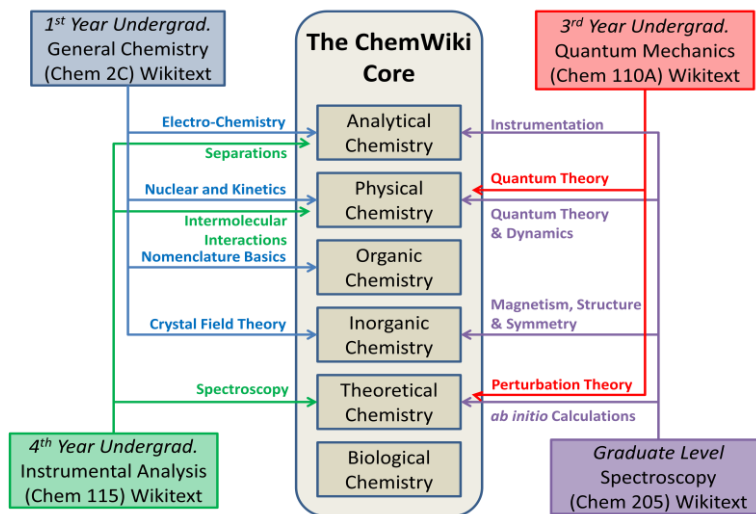
**Figure 1:** (Left) Daily traffic for student usage of Chem 2C Wikitext (3rd quarter Gen. Chem. at UC Davis). Spikes originate from students “cramming” before exams. (Right) Integration

## Scheme of Hyperlibrary

Two primary factors separate the Hyperlibrary from other projects with similar goals. The first factor is that the Hyperlibrary's intrinsic collaborative developmental approach introduces a powerful combination of flexibility, adaptability, and applicability that is capable of addressing a range of different classes. This enables faculty to adopt and adapt Hyperlibrary materials to suit their specific purposes. The second factor is that the Hyperlibrary content is connected within a dynamic *network* extending both horizontally (across multiple fields) and vertically (across multiple levels of complexity). This offers students and faculty, not just a single hypertextbook as with repositories, but an infinitely large *hyperlibrary* of interconnected textbooks. This strongly integrated nature allows the STEMWikis to be exceptionally flexible in addressing both current and future education needs and new approaches.

### The Core/Wikitext Approach

A well-functioning textbook (whether hyper- or conventional) is much more than just a series of reference topics found in encyclopedias or Wikipedia, but must address additional aspects: 1) An established flow between previously discussed, current and future content and 2) A complementary set of questions to aid student internalization of the text material. Key to the utility of the ChemWiki is its intrinsic flexibility necessary to suitably address these aspects. All Modules containing information are contained in the Core (Figure 2) and "Wikitexts" are individually constructed for specific classes by creating a hyperlinks structure to the **Core** Modules.



**Figure 2:** Illustration of how the Core/Wiktext enables the flexible design of a variety of hypertextbooks for courses at all levels of instruction and subfields. Course numbers are for UCD. Different Modules will coexist addressing the same topic, but at different levels allowing for addressing classes simultaneously.

The Core/Wiktext approach provides a powerful flexibility in introducing and removing content without affecting other concurrently operating classes and provides the flexibility for instructors to construct Wikitexts that best suit their needs (e.g., ignoring non-integral topics). Each Module contains metadata that outlines the recommended Modules necessary for students to have read prior to the Module to receive a full understanding of the content contained therein. For example, an instructor can construct a **Wiktext** by generating a list of hyperlinks to Core Modules in the order that best fits the class flow or pedagogical approach. If existing Core Modules are insufficient for course goals, new ones can be easily generated from existing vetted ones via the ChemWiki's graphical editor. Existing **Wikitexts** are available for instructors to peruse, adapt, and adopt.

Since March 2014, the ChemWiki has been used as the exclusive textbook in **seven** different classes involving **six** different instructors over **four** campuses in **two** states. These seven classes alone have saved students ~**\$500,000**.

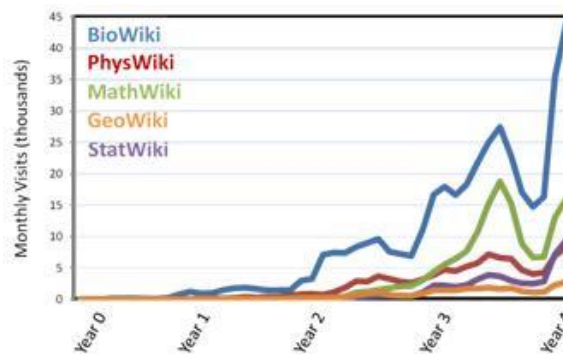
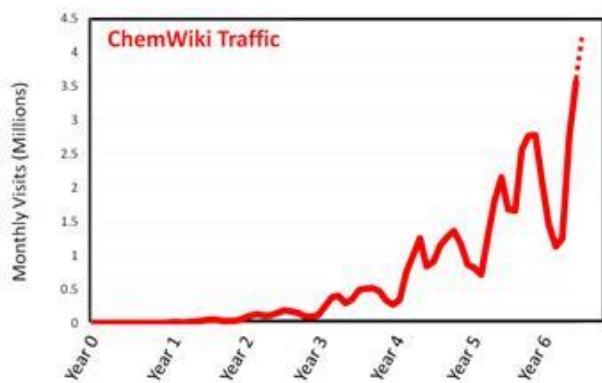
Instructor	When	Course	Campus	Enrollment	Text Cost
<a href="#">Delmar Larsen</a>	Spring 2014	General Chem (3 <sup>rd</sup> Q)	UC Davis	500	\$250
<a href="#">Delmar Larsen</a>	Summer 2014	General Chem (3 <sup>rd</sup> Q)	UC Davis	300	\$250
<a href="#">Joshua Halpern</a>	Fall 2014	General Chem (1 <sup>st</sup> Sem)	Howard U.	95	\$273
<a href="#">Dianne Bennett</a>	Fall 2014	General, Organic, Bio	Sacramento City College	100	\$180

<b>Paul Wenthold</b>	Fall 2014	Organic Chemistry	Purdue U.	220	\$275
<b>Mark Lipton</b>	Fall 2014	Organic Chemistry	Purdue U.	93	\$160
<b>Tomoyuki Hayashi</b>	Fall 2014	General Chem(1 <sup>st</sup> Q)	UC Davis	500	\$250
<b>Misc.</b>	2008-Present	Instrumental Analysis	UC Davis	300 to date	\$30

### Evidence of ChemWiki's Success

While the dynamic nature of the ChemWiki and greater Hyperlibrary, means that they are under constantly construction, several recent developmental traits are of particular interest:

- The ChemWiki has been exponentially growing and now reaches ~4 million students and 5.5 million pageviews monthly.
- The ChemWiki is the most visited chemistry website in the world and most visited on UCD campus by a large majority.
- One in four internet visitor to UCD campus go to the ChemWiki and it is expected that by next year, the ChemWiki will exceed the rest of campus internet traffic combined.
- Three non-UC campuses (Purdue U, Sacrament City College, and Howard U) have started using the ChemWiki for their classroom needs. Approximately \$500,000 have been saved in textbook expenditures to date



**Figure 3:** Integration Scheme of Hyperlibrary (top). Monthly visitor traffic profiles for the ChemWiki (middle) and five other STEMWikis (bottom) since project initiation. Dotted line is projection of traffic to December 2014

### **Data Driven Pilot of ChemWiki Efficacy**

Preliminary results of a data-driven quantitative three-quarter pilot to test the efficacy of the ChemWiki are positive. The effectiveness of the ChemWiki was assessed during the spring quarter of 2014 in the third quarter general chemistry course at UCD. The experimental class (n = 478) used the ChemWiki as its primary resource, while the control class (n = 448) used the standard textbook for the general chemistry sequence. Both classes were taught back-to-back by the same instructor (Larsen) with the same set of teaching assistants and assessment protocols.

Both classes used the same exams designed to measure the overall learning gain of the students in both classes, which were also confirmed with pre/post exam comparisons. The results showed that the normalized learning gains for both classes were not statistically different when accounting for student demographics. The Colorado Learning Attitudes about Science Survey (CLASS) chemistry survey was employed at the beginning and end of the quarter to determine if either class's beliefs about chemistry changed based on the primary resource they used; results from the survey showed that both classes were not statistically different. A weekly time-on-task survey was developed to monitor the hours spent working on the material outside of the classroom. The student reported data showed that the average student in the experimental class spent ~0.4 more hours a week studying. We confirmed the self-reported data in the ChemWiki section by comparing the number of hours a student reported to the number a page views on the ChemWiki they had. Furthermore, high ChemWiki using Students (>400 total page views) showed about an 8% increase in course performance.

We encourage faculty participation in adapting and adopting of the ChemWiki; in particular, we are looking for faculty interested in contributing existing content to the ChemWiki and fostering its integration into its existing infrastructure (either directly or via fostering student participation). Contact Delmar Larsen (dlarsen@ucdavis.edu) for more details about contributing or using the ChemWiki or greater Hyperlibrary project.