The Science of Spectroscopy: Collaborative curriculum development and applications-based learning using a wiki

Stewart Mader
Brown University

Abstract
A Wiki can be thought of as a combination of a Web site and a Word document. At its simplest, it can be read just like any other web site, but its real power lies in the fact that groups can collaboratively work on the content of the site using nothing but a standard web browser. The Wiki is gaining traction in education, as an ideal tool for the increasing amount of collaborative work done by both students and teachers. Students might use a wiki to collaborate on a group report, compile data or share the results of their research, while faculty might use the wiki to collaboratively author the structure and curriculum of a course, and the wiki can then serve as part of each person's course materials. Recently The Science of Spectroscopy, a well-known educational web site, was converted into a wiki so that the growing number of readers can now become writers and collaboratively build a richer and more useful tool.

What is The Science of Spectroscopy?

The Science of Spectroscopy was developed to engage students by first presenting a wide variety of applications, then leading to theory as the underlying explanation. From NASA projects to medical imaging, sunscreen chemistry, and microwaves, the applications are intended to appeal to the different interests of as many students as possible, and encourage them to understand how and why spectroscopy is used. This creates a learning environment in which theory and techniques can be taught as the explanation for how applications work, so that students see relevance and meaning as they learn theory and techniques, instead of seeing it as useless and uninteresting.

The Science of Spectroscopy started in 1999, and as the site received publicity from reviews, publications, and conference presentations, an increasing number of users sent materials for us to add to the site, so it would better complement their lessons and assignments. As the requests increased, it became apparent that a system was needed to support this growing community, and engage teachers by allowing them to directly shape the resource they were using. The most important criterion in doing this was simplicity - whatever tool we decided to use had to make participation for teachers as simple as possible, so they would not be distracted by complicated technology. The wiki emerged as the best tool to do this. At its simplest, it can be read just like any other web site, but its real power lies in the fact that groups can collaboratively work on the content of the site using nothing but a standard web browser. Beyond this ease of editing, the second powerful element of a wiki is its ability to keep track of the history of a document as it is revised. Since users come to one place to edit, the need to keep track of Word files and compile edits is eliminated. Each time a person makes changes to a wiki page, that revision of the content becomes the current version, and an older version is stored.

Versions of the document can be compared side-by-side, and edits can be “rolled back” if necessary.

Why did we start using a wiki?
When technology tools only attract adventurous, early adopters, it's because:

- The tools to create content have complicated user interfaces, and require a significant amount of time just to learn how to navigate the interface and work through tutorials before anything useful can be created.
- The high cost of tools has discouraged or priced teachers out, even when they have the knowledge and expertise to build high quality learning tools.
- Copyright law is detailed, lengthy, and difficult to understand, so most teachers don't have the time or expertise to understand it. The gray areas in copyright law are so misunderstood and murky that if you ask ten different people, you'll get ten different answers, and each one will likely be to the benefit of the person answering you. This is a reflection on the complexity of the issue, and makes it really easy to see why people don't know what to do with materials.

Because of its deliberate design to let authors focus on content over technology, familiar operation (uploading an image is like attaching a file to email, creating a link involves a syntax that looks more like natural writing than machine commands), and very low cost compared to most software, the wiki is showing potential to change how information is handled and built - potential whose precedent seems second only to the Internet itself. At its core, it really does enable people with knowledge and expertise in an area to focus on sharing their knowledge and collaboratively authoring materials. Coupled with the wiki, the growth of Creative Commons licensing is a critical catalyst because it provides an "in-between" full copyright and public domain, and a recognized way to give authors proper credit while legitimizing community editing and improvement so content stays fresh, comprehensive, and useful.

We've applied the wiki to The Science of Spectroscopy to:

- Create a clear, logical platform for any user to contribute content to The Science of Spectroscopy
- Involve teachers who might otherwise be less compelled to use technology because they don't have time to develop technology based learning materials from scratch, or have been disengaged by the unnecessary complexity of some tools.
- Ensure the long-term usefulness of The Science of Spectroscopy by creating a cycle of sustainability in which the content submitted keeps the resource relevant, and the resource’s ease of use encourages any educator to submit content
- Introduce new content topics, such as cutting-edge applications of spectroscopy in astrobiology, space science and medicine, through collaboration with scientists in industry and academia.

- Increase the worldwide usability of The Science of Spectroscopy by hosting versions in multiple languages. The first translation to French is designed to serve the significant Canadian and French user base of the web site. This serves as the starting point for conversion of content to other languages which reflect the site's user base, such as Italian, German and Spanish, and the wiki makes translation feasible because users can work directly on pages, and translations are available the moment they add them.

How did we design it?
"...there is no physical analog to a wiki" a tool that has an, "interface that allows multiple authors to simultaneously collaborate on multiple documents...It's something that I, and many designers like me, are working out as we go along.[1] A Wiki is both a technology tool and a community forum, and is unique in that it has no physical counterpart. This makes it both challenging because there's no exact historical precedent to guide the development of wiki software, or the conduct of wiki sites. This is also very liberating, and an example of the era we are just entering with technology, where new tools only exist in the online realm because they take advantage of maturing architecture that is only possible online.

For example, in order to make "writing" to the web easier, the makers of Wiki software have created a syntax that simplifies the code and reduces the time needed to perform common functions, like linking. Using HTML, a link would be written:

Skysight
and would appear in a Web browser as Skysight. Using Wiki syntax, the same link would be written:

[http://www.scienceofspectroscopy.info/skysight Skysight]
and would appear in a Web browser just like the underlined link above.

For The Science of Spectroscopy, we designed the wiki to be as self-sufficient as possible, using the same, applications-first structure that initially made the site unique. The wiki main page has just three lists: Applications, Techniques, and Theory, and links can be quickly added as new pages are created. The only part of the wiki that is not "self-service" is account creation. New users must email a request to have their accounts created, so that we can screen out spammers and deter vandals or people looking to boost their search engine rankings by posting lots of links on wiki pages.

How criticism helped articulate the value of the Wiki
In January 2006, I was contacted by a professional organization for spectroscopy, which wanted to link to The Science of Spectroscopy. After we agreed on the link, etc. the organization's web editor indicated that he opposed the link because he felt that the content in The Science of Spectroscopy was not as extensive as the content in Wikipedia. Here's my response:

"The Science of Spectroscopy is quite different from Wikipedia, and the point of putting material on a wiki is to encourage others to make it more comprehensive, better, etc. as they see fit. As much as I respect Wikipedia, I think that we'd all be ill served if one person decided not to improve one site just because he thinks another one is better. There are people who place a lot of credibility on the fact that people have to request accounts to use The Science of Spectroscopy, which allows us to screen out vandals and those looking to improve their own site rankings in search engines by randomly posting links wherever they can.

While Wikipedia has a large volume of information befitting its role as an encyclopedia, the most important goal of The Science of Spectroscopy is to provide a place and a community where educators can come to work on curriculum together, using simple technology that transcends traditional school and geographical boundaries. Also, the way the wiki catgorizes information by Applications, Techniques, and Theory, with Applications visible as the starting point is based on the original goal of the project. We want to engage students by showing how spectroscopy is important to their daily lives, and get them to ask why something works the way it does, so that when we teach theory they see it as meaningful, and more than just numbers or equations.[2]

Models for wiki use in education & next steps

The Science of Spectroscopy represents how the wiki can be used as a platform to bring teachers together across institutional and geographical boundaries, but the wiki can also be applied to single courses, or multiple sections of the same course. One model I'm working with right now involves multiple faculty teaching a freshman level science course. Historically, the responsibility for teaching courses like these rotates to different people every year, and the content either gets "reinvented" every time new people teach, or carried forward sporadically based on whether the outgoing teacher is willing to share materials with the incoming teacher. Enter the wiki - if all the teachers involved put their materials on the wiki, they can collaboratively build and refine the curriculum, enabling it to better keep pace with changes in science. The wiki can then serve as part of each person's course materials, and can become a platform for student collaboration as well. Applying the wiki to a course in this manner can set the stage for collaboration in a larger, cross-institutional project like The Science of Spectroscopy.

The applicability of the wiki to education extends beyond collaboration among teachers, and can have an equally transformative effect on the way students work. Another model I'm testing is to use data collected by students in a wiki to make in-class presentations more "real" and relatable to the students. In this way, the wiki might be coupled with active learning methods like Just-in-Time Teaching (http://www.jitt.org), "a teaching and learning strategy based on the interaction between web-based study assignments and an active learner classroom. Students respond electronically to carefully constructed web-based assignments which are due shortly before class, and the instructor reads the student submissions 'just-in-time' to adjust the classroom lesson to suit the students' needs. Thus, the heart of JiTT is the 'feedback loop' formed by the students' outside-of-class preparation that fundamentally affects what happens during the subsequent in-class time together.[3]

Besides blurring the boundaries of the traditional physical classroom and extending the time limits of the traditional class schedule, the wiki also has the potential to have students learn in the same environment and context that they will work professionally in.

Call for Participation
Imagine a class of 20 students taking analytical or organic chemistry.

In the first scenario, the class is a control group, with all units taught in a standard lecture format and assessment by regular problem sets, quizzes, and exams.

In the second scenario, the units of the course dealing with spectroscopy are taught using the wiki as a collaboration and publishing tool. Students are introduced to The Science of Spectroscopy as the applications-based learning resource. Working in groups that resemble scientific research groups, they choose a topic from the site that also relates to the course or propose a new topic for addition to the site, with the understanding that the paper they produce will be peer-reviewed and published directly on the wiki. Each group uses a private wiki page as their central information gathering space as they research the scientific literature and informal science publications (such as Scientific American, NewScientist, digg.com). They then take the information gathered and prepare a paper on the topic, using the wiki as collaborative writing space. Along the way, the teacher provides guidance on their draft, just like a colleague might do for a paper to be published. Once papers are finished, each group submits their paper for peer review by the teacher (and perhaps one or two other teachers if possible). Comments are posted directly on the wiki, and each group is given time to incorporate them before real publication in the appropriate topic page on The Science of Spectroscopy.

Which scenario do you think the students will learn more from? If you're willing to help find out, I'm looking for several courses to test the second scenario in Fall 2006. Please contact me at slmader@gmail.com

References Cited

1. Elfving, Dave. "A Better Collaborative Interface." Machine Chicago. <http://www.machinechicago.com/> (4 February 2006).
2. Mader, Stewart, "Fwd: SAS/The Science of Spectroscopy links," slmader@gmail.com 31 January 2006, personal email.
3. Novak, Gregor, What is Just-in-Time Teaching? http://webphysics.iupui.edu/jitt/what.html (30 April 2006).