A TALE OF TWO WIKIS: UPPER-LEVEL MATHEMATICS MEETS WEB 2.0

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1. Upper-Level Mathematics Courses and Wikis

When college mathematics departments refer to "upper-level" courses, they usually mean those courses whose catalog labels indicate they are for juniors and seniors majoring in mathematics. These courses typically include Abstract Algebra, Real Analysis, advanced courses in applied mathematics, senior research projects, and the like. The catalog copy for such courses can strike disbelief and fear into the hearts of even the most self-assured students. Indeed, many departments have a buffer zone of "transitional" or "bridge" courses in the sophomore year to ensure as smooth of a ramp-up as possible from Calculus I and II into the upper levels of the curriculum.

What makes upper-level courses so different than lower- or transitional-level ones? We cannot say it is because upper-level courses are “abstract” or “proof-based,” because often such courses are neither (for example, mathematical modeling or applied statistics courses). The distinction instead can be seen by considering the model of cognitive tasks first devised by Benjamin Bloom ([2]), commonly known as *Bloom's Taxonomy*, which was updated recently by L. W. Anderson and D. R. Krathwohl ([1]).

Anderson and Krathwohl divide cognitive tasks into six domains of increasing sophistication: *remember*, *understand*, *apply*, *analyze*, *evaluate*, and *create*. It is the emphasis on *creating* that really distinguishes upper-level mathematics courses from the others. This creativity may take the shape of a proof to a theorem the student has read or discovered, a statistical analysis of real-world data for a client, or a mathematical model created to understand some complex process. But whether proof-based or application-based, whether abstract or concrete, the focus in an upper-level mathematics course is on *making something new*.

Often, the creative work in upper-level courses is done collaboratively, whether among team members in the class, between a student and a client, or between a student and a research advisor. This kind of collaboration is quite different from the group work a student might do in, say, a calculus course, in that the collaborators are dependent upon each other to accomplish the creative act required in the course.

A useful technological tool for enabling the creativity and collaboration in upper-level mathematics courses is the *wiki*. A wiki is a web site in which the content is created, organized, and maintained by the users of the web site rather than by a central authority. The most famous example of a wiki is the online encyclopedia Wikipedia. Wikis have potential for use in upper-division courses because they allow students to work collaboratively on projects to combine text, mathematics, and multimedia content in a single, editable space.

We will now describe two cases where wikis were used by students in upper-level courses at Franklin College to facilitate the collaborative and creative work that one expects from such courses.

2. Wiki #1: Documenting Cryptology During World War II

MAT 300 at Franklin College is "topics in mathematics" course. I have taught the course twice with a focus on cryptology. This subject has not only an exciting present and future but also a rich history. A primary goal of the course is to place cryptology into its historical context, so that the modern applications of the subject can be seen as the results of an intellectual and technological evolutionary process.

The first time the course was offered, the primary way students were to address this goal was through a library research project which could focus on individuals or historical eras in cryptology. Many good projects emerged out of this assignment. However, some issues arose which hampered students' understanding of the "big picture". First, students tended to focus intently on their own project topic but never had an opportunity to explore the connections between their topic and other topics. Second, students tended not to interact with each other, because there was no incentive for a pair of students, working on different projects, to collaborate and make each others' work better.

To get past this issue, during the second time the course was offered, the research project assignment was replaced by an assignment in which students were to work together to create a wiki whose general subject was cryptology during World War II. The result can be found at http://enigma.wikispaces.com.

The platform for this wiki was Wikispaces (http://www.wikispaces.com). Wikispaces was chosen because it is free, hosted off-site, and allows intuitive content management through a WYSIWYG editor for articles and several helpful authoring features. Students (and the professor) could track any changes to the wiki through an RSS feed.

Students were tasked with accumulating at least 50 points' worth of activities in the creation of the wiki, which could come from writing brief articles, adding media, adding links to other students' pages, or making significant additions or edits to existing articles by other students. Authoring an article was worth five points, and students were required to write at least three articles; all other actions were worth one point. Therefore 15 points out of 50 must come from authoring articles, while the remaining 35 could come from whatever combination of actions the students wanted.

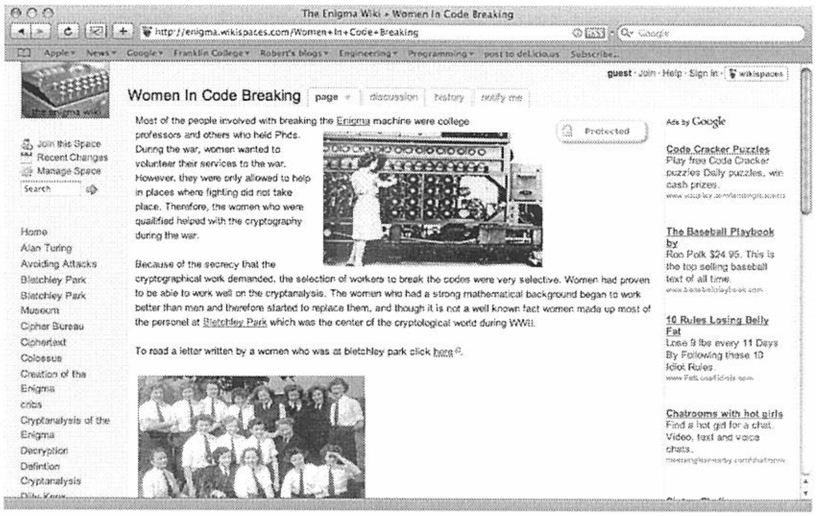

Figure 1: An article from the Enigma wiki.

The use of a wiki instead of a standard term paper allowed students to gain not only depth in the areas they chose but also breadth by linking to and editing the works of others. Students were given credit for links and edits only if the link or edit involved a page that they did not write, thus ensuring a high level of collaboration. And since students could write about whatever topic they felt the most interested in, and since they could include not only text but multimedia as well, the students were rewarded for their curiosity and creativity with the material.

3. Wiki #2: A Student-Generated Abstract Algebra Solutions Manual

MAT 361 at Franklin College is a standard course in abstract algebra. For the most recent offering of the course, I decided to teach the course using the Moore method ([3]). This meant that most class meetings consisted of students going to the board to work out solutions to problems, exercises, and other questions posed in a set of class notes which I prepared. Lecturing occurred only at the outset of the course and at times when students needed additional clarification on a topic which they could not provide themselves.

In order to do the problems in the course notes, students must have a good understanding not only of the problem which they are working, but also the related problems prior to theirs, which other students had done. Such an understanding of prior problems involves not only an accurate and complete transcript of the solution done at the board, but also a grasp of the overall strategy being employed. The former can be accomplished through good note-taking; the latter is best accomplished by careful listening and is often hampered by assiduous note-taking. Students needed a central repository of trustworthy solutions to problems to relieve them of the onus of note-taking, while not removing from them the responsibility of writing up their work. Such a repository would, ideally, be searchable for use in problem-solving tasks.

The solution created for this problem was a wiki, again using the Wikispaces platform, to serve as a student-generated and -maintained "solutions manual" for the course. This can be accessed at http://modernalgebra.wikispaces.com.

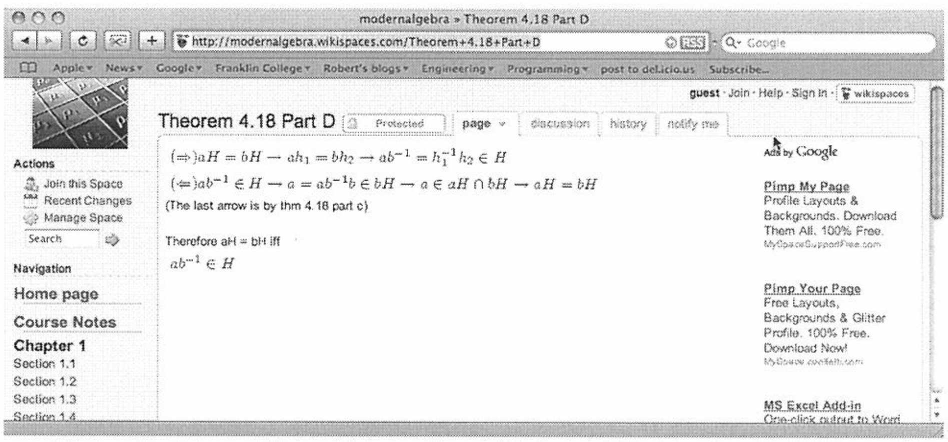

Figure 2: A proof from the modern algebra wiki showing LaTeX use.

Students who presented work at the board were responsible for writing up each solution as an article on the wiki. One of the attractive features of Wikispaces is that LaTeX code can be entered in through the editor and is automatically compiled when the page is updated. Therefore, students could write up professional-looking solutions with complicated mathematical notation for other students to read, edit (if necessary), and discuss.

The search feature of the wiki was particularly useful for students. If a student were responsible for working a problem about abelian groups, s/he could simply type in "abelian group" into the search box (in the center-right of the figure above) and obtain all wiki entries containing that text, thereby allowing a fast and foolproof means of looking at similar and related problems.

Unlike the Enigma wiki, this wiki was entirely ungraded. Instead, all timed assessments in the course were "open-wiki". Students were allowed to use laptop computers on the timed assessments and could use a web browser to access the wiki for worked problems.

Thus, although students received no direct credit for writing good wiki entries, there was a strong incentive to do so and to write them well (and to edit the ones which were not written so well).

In this instance, again the wiki facilitated the creative work of students in the course, which here consisted of writing proofs of theorems and other mathematical results. The discussion and editing features of the wiki allowed students to interact with each other on that creative work and genuinely make each others' work better.

4. Conclusion and Prospects for Further Uses

The collaboration and creativity which set upper-level courses apart from lower- and transitional-level courses is hard work. Students need not only preparation for that work but also tools which enable them to do the work well and enjoy doing it. Wikis are an attractive and useful tool for this purpose, being online, inexpensive, easy to use, and multimedia-friendly. Wikis also benefit from the near-ubiquity of Wikipedia in that students are likely familiar with the concept and look-and-feel of a wiki before they try to use one.

We have sketched here only two uses of wikis in the upper-level classroom. Nearly any kind of creative or collaborative work among upper-level students could be enabled with a wiki. Some examples of further use would include collaborative note-taking, in which a student each class day would be tasked with producing notes from the class meeting and putting them online for students to edit and discuss; or even using a wiki as a course management system in which course information and documents are posted and updated on a continuous basis.

5. References

[1] L. W. Anderson, D. R. Krathwohl. *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. New York: Allyn & Bacon, 2001.

[2] B. S. Bloom. *Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain*. New York: David McKay Co Inc., 1956.

[3] D. W. Cohen. A modified Moore method for teaching undergraduate mathematics. *The American Mathematical Monthly*, Vol. 89, No. 7, pp. 473-474+487-490 (Aug.-Sept. 1982).