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Student Editor for the Organic Chemistry Wiki Project 6/1/08-5/31/09
$4660

Original Goals and Objectives:

As part of a campus-wide calendar and curriculum revision at Furman University, the chemistry department reinvigorated its introductory organic chemistry sequence. The traditional model, used at virtually every U.S. college and university, presents the canonical material over a two-course sequence. In contrast, we now offer a two-term, two-course sequence where the first course meets four days per week and is an accelerated offering of the canonical material (alkanes through carbonyl chemistry) and the second course meets three days per week and focuses on bio-organic chemistry (protein structure, enzyme and cofactor mechanisms, nucleic acid structure, drug design, carcinogens and chemotherapeutics, biosynthesis of natural products, and the molecular basis for and treatment of disease). The enhanced biological emphasis of our new course sequence gives our students an organic chemistry experience that is more relevant to their future careers in the health professions and in research at the interface of chemistry and biology.

The major challenge facing such an approach is the lack of an appropriate textbook for the bioorganic chemistry course, which testifies to the originality of our course content. This challenge is similar to the one faced by many faculty teaching advanced courses of their own creation for which no existing textbook seems appropriate. An effective, and commonly-used, solution to this problem is the cobbling together of resources from textbooks, literature readings, and faculty-created supplementary materials to make a coursebook tailored to the needs of the specific course. However, as we considered this option for our bio-organic chemistry course, we saw an opportunity to instead use a student-centered approach for the organization of course content consistent with Furman's commitment to "Engaged Learning." This decision was motivated by the established body of research that indicates students tend to learn best when they are active participants in the creation and organization of knowledge (Crouch & Mazur, 2001; Farrell, Moog, & Spencer, 1999; Gaffney, Richards, Kustusch, Ding, & Beichner, 2008; Hake, 1998; Springer, Stanne, & Donovan, 1999; Wright et al., 1998).

Our approach to the construction of the bio-organic electronic course text borrows from the successes of wikimedia as exemplified by Wikipedia. Wikipedia is an example of a wiki, a web site to which anyone may contribute and modify content. The Wikipedia experiment has demonstrated that, over time, a community of contributors with varied backgrounds and abilities can collaborate in the creation of organized knowledge with a breadth and accuracy that rivals that of traditional encyclopedias (Giles, 2005). We hypothesize that, over time, a community of students with varied backgrounds and abilities will collaborate in the creation of organized knowledge with a breadth and accuracy that rivals that of traditional textbooks. Furthermore, such e-textbooks are inherently more inclusive across gender, racial, and geographic boundaries than more traditional texts because they better incorporate the unique perspectives of many individual student-authors. To realize these outcomes, students must be empowered with the skills to create, evaluate, and modify a course wiki, thus allowing students themselves to generate the text for their course. Future students in the course would then use, augment and edit existing content. In this manner, each subsequent class will have the responsibility of improving the electronic text, with the desired outcome being a resource that better reflects students' ways of learning rather than our ways of teaching. Though wikimedia has been used successfully for many years in academic settings, (Mader, 2008) to the best of our knowledge the use of wikimedia in the student-led creation of a dynamic, electronic course text for an original course is unprecedented. A key feature of the ACS grant was funding for the appointment of a student editor-in-chief to manage development of the wiki.

Accomplishments Prior To and During the Grant Period:

Because our new bio-organic course was not offered until the Fall of 2008, we opted to beta test the development of this e-textbook technology in our existing introductory organic chemistry course in the Fall of 2007. Though this course uses a popular and established textbook, and thus is quite different from the bio-organic course on which our proposal is based, we felt through this exercise we could learn a significant amount about the mechanics of and challenges associated with generating an e-textbook. Since an important objective of this project is to develop a platform that is broadly accessible to any faculty member at any institution, we felt it was important to use a wiki engine that is available at no cost. During the summer of 2007, we evaluated five free wiki platforms against our primary criterion of ease-of-use (Moodle, PBWiki (now PBWorks), Plone, MediaWiki and Wet Paint). A WYSIWYG (what you see is what you get) editor was considered essential, given that most students do not have the

experience in computer programming necessary to use an editor with a programming interface that is significantly different from the editor of the popular WYSIWYG word-processing program Microsoft Word. We also desired a platform that was tolerant enough to allow someone with limited programming knowledge to program small modules and install them on the wiki to simplify certain repetitive tasks. Finally, the platform needed a robust history feature; one that both records the contributions of individual students (which is useful for grading) and that allows any previous version of a particular page to be accessed and reloaded (which is useful in case valuable content is accidentally erased by a student during the course of editing).

Of the five platforms, PBWiki best met all of our criteria, and we launched the e-textbook project in the PI's Fall 2008 sections of organic chemistry. The PI created a home page for the site (Figure 1), and at the time of the project launch, only this home page had information on it. Each subsection in the home page index corresponded to a subsection of the text and had a link to an empty wiki page of the same name. To prepare the students to contribute to the wiki, the PI designed a computer laboratory exercise that accomplished two important objectives:

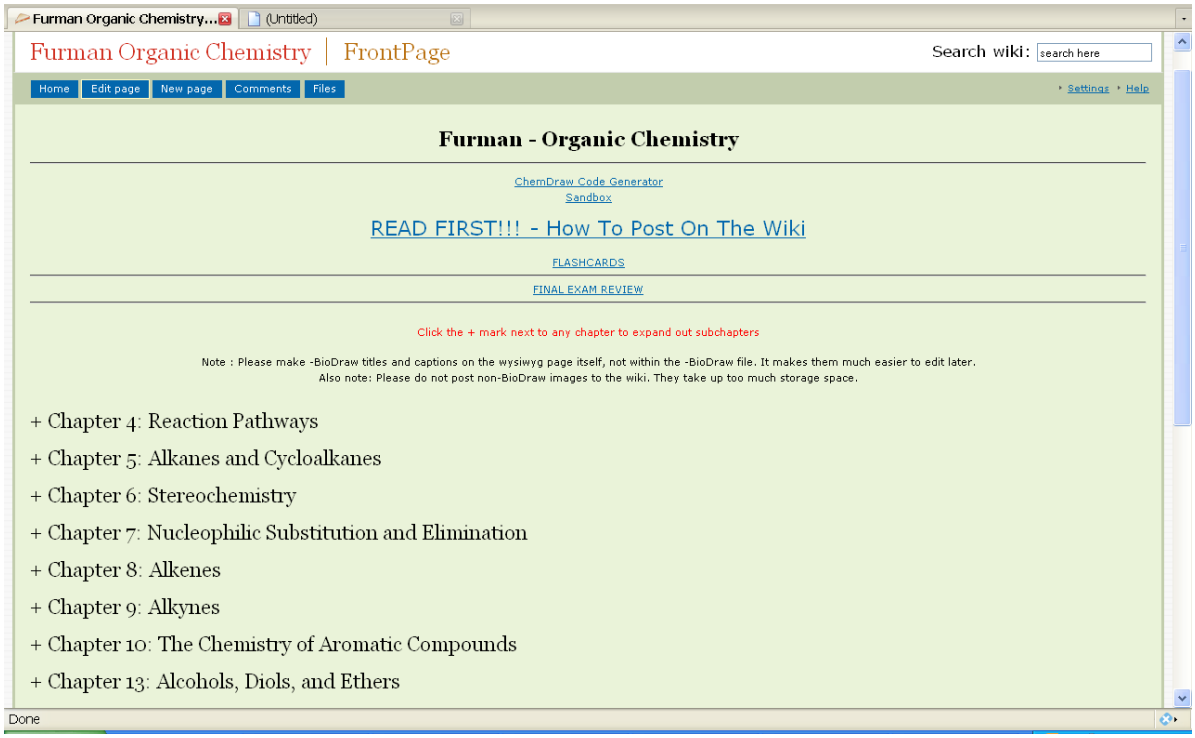

Figure 1. Table of contents page of the wiki created using the free and publicly available PBWiki engine.

(1) Students learned to navigate the wiki, create text, and upload documents of their own creation to a specific "sandbox" area of the site. Providing a sandbox area for practice that is not

associated with the primary content of the wiki helps students build confidence in their wiki-posting skills before they attempt to modify the shared wiki content.
(2) Students learned how to edit existing content on the wiki. Editing text is trivial via the WYSIWYG editor. The editing skill is essential to the long-term success of the e-textbook. Through editing, thousands of students have the ability to analyze, learn from and improve existing content. In this manner, content that is deemed optimally useful tends to persist without modification, and content that is incorrect or not presented in an optimal way is improved.

During the term students were expected to make an average of one wiki contribution per week. A small portion of their class grade was assigned based on their effort, as assessed using a PBWiki tool that associates created content with the name of its creator. With 70 students in the class, more than 700 posts were created in the first four months of the project (Figure 2). One group of students showed particular creativity by creating and posting videos of what they called "chemical reactions described in interpretive dance" (Figure 3).

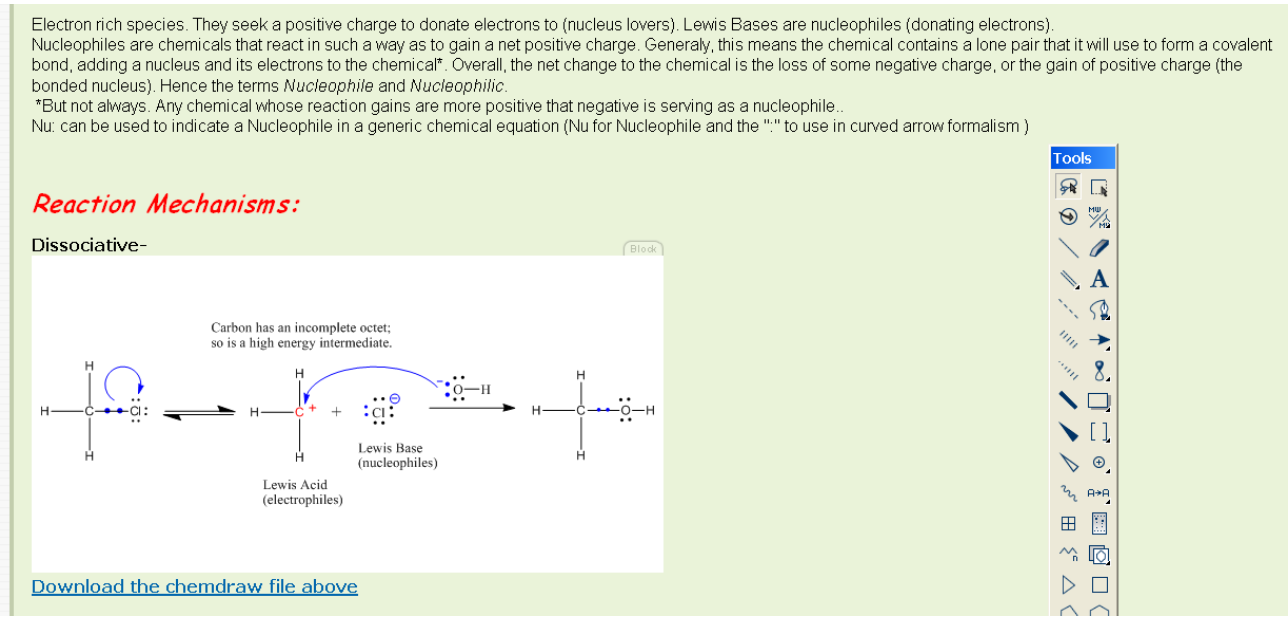

Figure 2. One of the hundreds of student-crafted wiki textbook posts (note that there are, indeed, some errors in the text). The diagram was also created by the student using a program called ChemDraw, a structure-creation tool that is essential to the communication of chemical information. The ChemDraw documents can be saved as image files and uploaded to the wiki.

Figure 3. Still-shot of a student-created video skit acting out a chemical reaction. The video was shot using a FlipVideo mini-camcorder. Uploading video is simple within a wiki setting.

With a solid foundation of existing content, we focused on editing skills with the class taking organic chemistry in Spring 2008. In addition to the posting requirements above, students were assigned the role of editor of two subsection pages. Their responsibility to those pages was to make whatever editorial improvements they felt were appropriate. The importance of the editing role cannot be understated. Only when students are given the ability to edit existing content can the e-textbook continually evolve into an ever-improving resource. Through the editing process errors are corrected, narrative explanations are made more clear, and descriptions are made more concise or more elaborate, depending on how valuable each new student perceives the existing content. We observed a dramatic increase in our perception of the overall quality of the posts once individual students felt editorial ownership of particular pages. Students also began to show significant independent creativity by creating additional wiki pages to handle specialized content. For instance, students created a page to post "e-flashcards" of practice reactions and a page designed around final exam review (see Figure 1, near the top).

It was clear early on that an editor-in-chief assigned to improve site aesthetics and to establish rudimentary organizational structure when new subsections are created would further improve the organization of our developing e-textbook. Though an instructor could, in principle, serve as editor-in-chief, a key feature of the e-textbook project is to create content that is the work of students and not of faculty, thus ensuring a text that reflects students' ways of learning rather than our ways of teaching. An instructor-editor is counterproductive in this regard. Moreover, the presence of instructor contributions may diminish students' willingness to critically evaluate all e-textbook content. The solution was the hiring of a student editor. This student had primary responsibility for the improvement of the wiki during the 2008 summer session and was selected from among those who participated successfully in the organic wiki

project during the academic year. We used the majority of our ACS grant to fund a stipend and housing allowance for this student editor. During that summer a number of tasks were accomplished by our student editor including formatting changes to improve the aesthetics of the e-textbook, creation of pre-formatted posting templates to improve the overall look of individual posts, creation of a "how-to" document with suggestions and shortcuts for making e-textbook posts, and generation of the rudimentary structure of the bio-organic chemistry e-textbook.

Assessment Efforts:

Our initial assessment instruments were developed in collaboration with Mike Winiski, an Instructional Development Consultant (IDC) in Furman's Center for Teaching and Engaged Learning (CTEL). Mike was an ideal advisor to bring into the project because he holds a bachelor's degree in chemistry, a master's degree in science education, and has developed skills in assessment strategies. These assessment efforts, also funded through the ACS-FRP grant, have fallen into three categories: (1) a Likert-scale questionnaire administered before participation in the e-textbook project designed to probe how well students' theories of intelligence, goal-orientation, and perception of the value of group work correlate with their participation levels in and perceived educational value of e-textbook creation; (2) a survey supplement to our standard course evaluations that asks students to evaluate their positive and negative experiences with the e-textbook project from a technical and educational standpoint; and (3) interviews of ten students following participation in the project designed to assess its educational impact. These instruments are included as Supplementary Documents.

Though we are still evaluating the results of the first year of the project in our organic chemistry classes, we have implemented meaningful changes based on the qualitative results of the surveys and interviews. Though the vast majority of student reactions to the e-textbook project have been positive, we have also uncovered a number of trends in student thought regarding the e-textbook project that merit further consideration. Some intriguing examples include a profound lack of comfort on the part of some students in having responsibility for creation of course content, nervousness about potentially incorrect information contained in wiki posts, and unease about the tentativeness of the information contained in the e-textbook. We recognize that these feelings are caused by the stark contrast in strategies required for information acquisition and transmission inherent to a student-developed e-textbook relative to canonical textbooks. However, responsibility for information content, skepticism regarding information accuracy, and acceptance of the fundamental tentativeness of scientific knowledge

are all important skills we hope to develop in the next generation of scientists, and we are encouraged that our e-textbook project has provided students the opportunity to confront these concepts early in their professional formation.

Based on our experiences with the above e-textbook creation for our organic chemistry course, in the Fall of 2008 we simultaneously launched both the new bio-organic course and the bio-organic e-textbook. This e-textbook contains no instructor-created content. The home page was designed by our student editor, who linked each daily lecture topic as a separate "chapter." Each student was assigned one lecture and was asked to create the corresponding chapter content for the e-textbook based not on what they thought would please an instructor or a textbook publisher, but on what they felt their friends and colleagues in their class and in future classes would benefit most from reading. Their source material consisted primarily of information from lectures and in-depth problem sets. Each student was also assigned to peer-review the content of another student's chapter, and all students were expected to edit their own chapter in light of the comments made in the peer-review returned to them by their classmate. A modest portion of the student's overall grade in the course was assigned by their instructor based on our perception of the amount of effort they expended on initial content creation, thoughtfulness of their peer review of their classmate's work, and the quality of their edits made in response to the peer review of their own chapter. The results were spectacular (for three sample chapters see the Supplementary Information). Hundreds of pages of illustrated content were created by approximately thirty students over twelve weeks.

Dissemination Efforts:

At the heart of the design of this project has been the need to make possible the execution of an e-textbook project at any institution for use by any group of students. Evidence of this design philosophy can be seen in the selection and development of the free, readily available, and easy-to-use PBWiki platform, seamless integration of text, text editing, image, and video capabilities, and efforts directed at finding a suitable platform for internal e-textbook hosting. Though the e-textbook described in this proposal is being produced for a specific course, we will formulate the *strategies* used to create our e-textbook into a model for e-textbook creation for any course in any discipline. I have already presented results of the e-textbook project within the Furman community and at two conferences: Lilly South (Greensboro, NC, 02/09) and New Media Teaching Conference (Elon, SC, planned, 8/09).

Future Directions:

The overarching goal of this project is to make available to all students a powerful tool for more active participation in the organization and communication of classroom information. Specifically, we plan to develop a general strategy for the generation of dynamic, electronic course textbooks that are created and edited entirely by students. We expect students participating in such e-textbook projects are more likely to become independent thinkers and learners than those who use more traditional texts. We also anticipate that, over time, the textbooks that emerge may be more useful to many students than those created by experts because they will have been created instead by those most closely associated with the struggles inherent to the learning process, the end-users of the information. *Toward this goal, we have submitted an NSF-CCLI proposal for $200,000 to facilitate achieving the following objectives:*

[1] We plan to demonstrate that students can create and edit a dynamic, electronic textbook to accompany a course, that this can occur without significant instructor intervention, and that students will find their e-textbook to be a more valuable resource than a traditional text. Our initial efforts will focus on establishing the proof-of-principle for this effort in our new introductory-level bio-organic chemistry course.

[2] We plan to generalize this process for use by any student in any institution and in any STEM discipline (indeed any academic discipline) by finding a no-cost, readily available, and simple to use electronic platform for e-textbooks creation that requires nothing more than internet access.

[3] We plan to identify and, where appropriate, develop assessment tools that gauge the efficacy of this pedagogical approach. In addition to measuring the impact of participation in e-textbook creation on specific organic and bio-organic learning outcomes, we will also measure changes in the way that students approach learning and changes in their perception of how scientific knowledge is created. Furthermore, we will identify how well their theories of intelligence, goal-orientation, and attitudes towards collaborative work correlate with their level of participation in and perceived value of this collaborative educational activity.

[4] We plan to disseminate this strategy to other faculty and institutions through publications and conference presentations so that there will be no significant barrier to adoption of this strategy by

any interested faculty member for use by any student regardless of gender, ethnicity, institution type, or geographic location.

Proposal Timeline:

The next stage of this project is directed at achieving the four goals listed above. There are a number of components that may be added to our existing bio-organic e-textbook to make it a more robust educational tool [Goal 1]. We must also explore additional potential e-textbook wiki platforms that have emerged since we initiated the project in 2008 to ensure we have found the proper balance between high quality and low cost [Goal 2]. In order to improve the impact of this instructional tool on student learning outcomes we must develop more rigorous assessment instruments. In-depth student interviews will be our primary assessment tool; we will follow three groups of students through both organic and bio-organic chemistry [Goal 3]. Finally, we must broadly disseminate our findings to the educational community [Goal 4]. A general sequence of proposed events along a three-year timeline is outlined below, each of which is elaborated in the proposal narrative that follows. During this timeline it is assumed that six new groups of approximately 60 students each will move through the bio-organic course, which is offered every fall and spring term, and will continue to improve the wiki chapters by creating and editing content, all under the supervision of a student editor-in-chief. The PI (an organic chemist) and co-PI (Greg Springsteen, a biological organic chemist) will coordinate all aspects of this timeline, will alternate teaching all sections of the courses described throughout this timeline, and will lead all activities not specifically assigned to an associated consultant. As the PI and Co-PI have directed the successful initial efforts on this project, we feel we are uniquely qualified to achieve these objectives (numbers in brackets refer to the goals above).

Spring 2010 : Bio-organic students will create a problem set and solutions "video manual". [1]
Creation of a parallel e-textbook on a pay-to-use platform will commence. [2]
Assessment exercises with organic chemistry (first course) students begin. [3]

Summer 2010: Bio-organic chemistry (second course) assessment tools will be developed. [3]
Begin conference presentations on e-textbook development. [4]

Fall 2010 : Continue video problem set development in bio-organic. [1]
Begin bio-organic assessment interviews. Continue organic assessment. [3]

Spring 2011 : Bio-organic students augment the e-textbook with links to outside resources. [1]
Continue bio-organic assessment, complete organic assessment. [3]

Summer 2011 : Assessment analysis begins. [3] Continue conference presentations. [4] Begin preparation of a manuscript for *Journal of Chemical Education* and *The Chronicle of Higher Education.* [4]

Fall 2011 : Begin incorporating student-suggested features into the e-textbook. [1] Complete bio-organic assessment. [3]

Spring 2012 : Continue incorporating student-suggested features in the e-textbook. [1] Begin summative evaluation. [2]

Summer 2012 : Complete summative evaluation. [2] Continue conference presentations. [4] Submit journal manuscripts. [4]

Proposal Narrative:

Improvements to the bio-organic e-textbook content:

Over the next two years our students will add two components to the bio-organic wiki textbook to enhance its utility. Each component seeks to preserve one of the important features of traditional textbooks that students enjoy, as determined by their responses on course evaluation forms. For instance, students consistently identify end-of-chapter problem sets and accompanying solutions guide as one of the most valuable components of their organic chemistry textbook. During the first year of this proposal period, we plan to open an avenue for inclusion of such material in their bio-organic e-textbook by asking students to videotape each other solving problems and posting those solutions to a new *Problem Sets and Solutions Video* section of the e-textbook. Again, students will be asked to shoot the videos as if they were talking about the problems to each other, not to faculty. This component of the e-textbook will require acquisition of 25 FlipVideo mini-camcorders. These camcorders are inexpensive, simple to use, and create files that can be directly uploaded to the e-textbook, as evidenced by the ease with which students independently conceived of, videotaped, and uploaded the video in Figure 3.

A second feature of traditional textbooks that students enjoy are the supplemental resources found either on in-chapter interest boxes and, in the case of more elaborate material, on an accompanying disc. Our e-textbook can accommodate both features simply through hyper-linking or uploading of existing web resources to the appropriate part of the e-textbook (we teach citation skills and plagiarism awareness as part of the course). By allowing students to decide which resources are included, only those they perceive as most beneficial will persist.

For e-textbooks to be successful in the long-term, they must include features that students find valuable. The two components mentioned in the preceding paragraphs incorporate elements

that students have told us they will find valuable in their responses to surveys. Following incorporation of these two features, the addition of new components will be at the sole discretion of participating students. In consultation with the student editor-in-chief, instructors will facilitate incorporating such suggestions.

Investigating alternate platforms for the bio-organic e-textbook:

PBWiki was adopted as the initial platform for the bio-organic e-textbook for three reasons: it is free and available to any individual or institution with access to the internet; it is simple to post and edit text, images and video; and it possesses a robust authorship tracking and version archiving feature. These features ensure broad accessibility of our application to any educational institution regardless of budgetary constraints, broad accessibility of the technology to any student regardless of programming knowledge, and ease-of-use for instructors both in grading and in the recovery of any data that may be lost due to inadvertent editing errors. In the intervening years since we began the project PBWiki has improved many features of its site, and we will continue development of our e-textbook on that platform to ensure a cost-free option for those who choose to emulate our model for student-generated e-textbooks.

However, allowing one's e-textbook to be hosted on another company's external server introduces potential hazards that must be considered, including: the possibility that the company discontinues the service, a lack of control over server outages during upgrades, no ability to easily create a back-up of your site, and a lack of freedom to add additional features. Schools with modest financial resources available to support an e-textbook project may prefer instead to purchase a wiki program site-license and host their e-textbook on an internal server. In anticipation of this need, in collaboration with Furman's Computing and Information Services, we have conducted an initial review of available wiki engines available for purchase in light of the needs of the e-textbook project. One program in particular, Confluence, is ideally suited to the task. It has all of the features of PBWiki listed above and provides adequate solutions to the problems with PBWiki listed above. As part of our efforts in the first year of the project we propose purchasing Confluence and an internal server to host a parallel version of our e-textbook so that institutions that are willing to make a modest investment in this option will be able to see by our example what can be accomplished. Furman's Computing and Information Services has agreed to provide consulting services to facilitate platform development (see Letter of Support).

Hiring a permanent student editor-in-chief:

Our early experiences beta testing the e-textbook concept pointed to a clear need for having a senior-level student serve as editor-in-chief of the e-textbook, with broad authority to maintain its overall aesthetic look, help train new students in the use of the technology, and suggest improvements to the design features within the e-textbook. The student editor also serves as a valuable intermediary between the students, who have complete control over the e-textbook content, and their instructors who, by design, do not participate in the generation and editing of content. Our experiences with our current student editor have been exceptionally fruitful. We propose hiring a student editor-in-chief for each year of this project. This student will be selected via a competitive application process from among those who have successfully participated in e-textbook creation in both courses and will be paid a modest academic year stipend and a full summer stipend. During the summers this student will assist in all areas of e-textbook development described in this proposal. We also propose purchasing a dedicated computer workstation so that our student editor will always have a desk and computer in our department with which to do his or her work on the e-textbook.

Assessment of e-textbook development (specific learning objectives italicized):

Inherent in the design of this e-textbook is the primacy of the student perspective in the evolution of the project. The instructor is a guide and motivator, but the students' efforts alone determine the trajectory and, ultimately, the impact of the e-textbook on their own learning outcomes. We have taken as a premise of this project that the final product of an e-textbook created over time by legions of students will have significant educational benefits that a canonical textbook cannot achieve (such as a dynamic ability to adapt to changes on a day-to-day basis, error resolution, student-centered perspective on strategies for concept-mastery, and active learning on the part of the reader/contributor). We take as a corollary to this premise that we instructors are far enough removed from the learning process required to master the concepts in our courses that our insights are not maximally relevant to the goal of creating the most-student friendly textbook. We consider our daily anecdotal experiences while teaching our courses as sufficient evidence for this statement. Students are constantly inventing clever strategies, mnemonics, and conceptual bridges that we, as experts, could never have envisioned. The e-textbook allows students to codify such creative insights for the benefit of future students.

The task of assessing the value of student-crafted e-textbooks will be challenging. This is true especially in light of the back-seat role of the instructor, which obscures easy determination of the value of any particular contribution to the overall learning goals of the project. Indeed,

higher test scores may be only one measurable outcome desired by an instructor who chooses to use our approach. In the specific case of our bio-organic chemistry course, we would consider the project a success if students reported gains in less tangible outcomes such as: *a better understanding of how knowledge is "created", codified, and organized*; *a better understanding of the tentativeness of "cutting edge" scientific knowledge, a better understanding of the responsibility of all scientists to their field for the unambiguous communication of information, a better understanding of the value of peer review*; and, perhaps most importantly, *greater enjoyment of their time spent with the material*. The PI of this proposal recognizes that he does not have the proper training to design instruments that assess progress towards these goals.

As such, this proposal calls on the assistance of two consultants from within the Furman community to assist with this important component of the project. Each consultant will be paid a stipend during the summer months to assist with both assessment and the implementation of changes based on an analysis of the assessment. The first consultant is Mike Winiski, whose contributions to the earliest phases of the project as an Instructional Development Consultant in Furman's Center for Teaching and Engaged Learning have been described above. Mike has pursued a career in the Scholarship of Teaching and Learning and holds an undergraduate degree in chemistry and is thus ideally suited to assist the development of the e-textbook project. The fundamental design of his plan is described below.

Bransford (2000) describes rich learning environments as those that are *student-centered, emphasize understanding over memorization, establish efficient feedback mechanisms for formative assessment, and foster the creation of a "community of learners"* (p. 23). This approach is in line with Furman's "Engaged Learning" education model. The e-textbook environment has the capability to support each of these characteristics. With a focus on student-created content, the wiki promotes ownership by the learner. Because students must understand a concept deeply before effectively teaching others through this medium, *deeper understanding* is a likely prerequisite to quality contributions. Wiggins and McTighe (1998) outline "Six Facets of Understanding" (p. 44), the first two of which (the ability to explain and interpret) are essential components of instructional e-textbook posts. The remaining facets (application, perspective, empathy, and meta-cognition) are potentially addressed in peer-review and authoring processes and may be illuminated through student interviews. The iterative nature of e-textbook contributions and ease in which classmates can provide feedback offers a gateway for *student-provided formative assessment* and a *virtual collaborative community*.

We intend to explore the impact of the wiki on student progress towards conceptual understanding of organic and bio-organic chemistry through several measures, which will be administered to classes participating in the wiki project and corresponding courses that do not utilize this resource, where appropriate. These measures include changes in student performance on the American Chemical Society standardized organic chemistry final exam, the Student Assessment of Learning Gains instrument, peer-to-peer ratings, and a pre- and post-survey.

The second consultant is sociologist Ken Kolb. Ken has experience designing, conducting, and analyzing in-depth interview data. Currently, he is leading the assessment of our university-wide First Year Seminar program. We will use his skills to craft assessment tools focusing on the effect participation in the e-textbook project has on our students' scholarly independence. The fundamental design of his plan is described below.

This project seeks to measure the impact that participation in e-textbook creation has on students' learning. This will be accomplished through in-depth interviews of three groups of students (36 total participants) who we will follow through both organic chemistry and bio-organic chemistry. By applying established qualitative data collection and analysis techniques, we hope to demonstrate the effectiveness of this teaching tool with valid and reliable data that capture the subtle changes in students' perceptions towards learning. In particular, we seek to determine whether *students who participate in the bio-organic e-textbook project are more likely to become independent thinkers than their peers in similar classes who do not contribute to an e-textbook*. To chart student's cognitive development, we will use the Perry Scheme for intellectual development (Perry, 1970) as a framework for assessment. Accordingly, we will assess whether or not participation in e-textbook creation has helped *students recognize that information can come from a variety of sources, including their peers, and that all information must be critically analyzed before it is accepted*. For this component of the grant we will need to furnish stipends for interview participants and transcribers and purchase transcription equipment to use in conjunction with the analysis software. These two consultants along with consultant support from Computing and Information Services form an advisory board that brings to the project specific expertise in the areas of chemistry education, assessment, and instructional technology that should prove invaluable to optimizing the success of the e-textbook project.

Dissemination of the results of the e-textbook project:

At the heart of the design of this project has been the need to make possible the execution of an e-textbook project at any institution for use by any group of students. Evidence of this

design philosophy can be seen in the selection and development of the free, readily available, and easy-to-use PBWiki platform, seamless integration of text, text editing, image, and video capabilities, and efforts directed at finding a suitable platform for internal e-textbook hosting. Though the e-textbook described in this proposal is being produced for a specific course, we will formulate the *strategies* used to create our e-textbook into a model for e-textbook creation for any course in the STEM disciplines. Thus, the communication of the results of our efforts to the broader educational community beyond Furman's campus is paramount and will take two forms. First, we will write a scholarly article on the development, implementation, and assessment of the e-textbook project for the Journal of Chemical Education (on the bio-organic e-textbook project specifically) and for the Chronicle of Higher Education (on the e-textbook project generally). We will use this opportunity to present the results of our assessment efforts.

Second, we will make presentations in the Education division of scientific conferences, beginning in chemistry (for instance, regional and national meetings of the American Chemical Society) and eventually broadening coverage to include meetings in the remaining STEM disciplines and conferences that span all academic disciplines. We will also post an overview of our project to the NSDL database, including instructions on how to start a new e-textbook. These instructions will invite faculty who have successfully started their own e-textbook project to communicate with us so that we may expand our NSDL entry to create a network of examples of student-generated e-textbooks. Such a list may encourage similar projects at more institutions.

Continuation of the e-textbook project:

We expect the impact of the e-textbook project will extend well beyond the grant period. Clearly the best way to help this education innovation take root is to facilitate the successful creation of e-textbooks at other institutions. For instance, schools wishing to develop a bio-organic course similar to Furman's may find our e-textbook a useful resource in planning an e-textbook project that suits their particular needs. Given the ease with which other institutions may emulate our project at no (or low) cost and the aggressive dissemination plan described in this proposal, our expectation is that persistent e-textbook projects will be found across all STEM disciplines at an increasing number of institutions in the coming years.

Proposal References:

Bransford, J., Brown, A., & Cocking, R. (Eds.). (2000*). How people learn: Brain, mind, experience, and school.* Washington, DC: National Academy Press.

Crouch, C.H., & Mazur, E. (2001). Peer instruction: Ten years of experience and results. *American Journal of Physics*, 69(9), 970-977.

Farrell, J. J., Moog, R. S., & Spencer, J. N. (1999). A guided inquiry general chemistry course. *Journal of Chemical Education*, 74(4), 570–574.

Gaffney, J. D. H., Richards, E., Kustusch, M. B., Ding, L., & Beichner, R. (2008). Scaling up education reform. *Journal of College Science Teaching*. 37 (5), 48-53.

Giles, J. (2005). Internet encyclopaedias go head to head. *Nature, 438*(7070), 900-901.

Hake, R. R. (1998). Interactive-Engagement vs. traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, 66(1), 64–74.

Mader, S. (2008). *Using wiki in education. Case studies from the classroom.* Available only from http://www.ikiw.org/

Perry, William G. (1970). Forms of Intellectual and Ethical Development in the College Years; a Scheme. New York: Holt, Rinehart and Winston.

Springer, L., Stanne, M. E., & Donovan, S. S. (1999). Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis. *Review of Educational Research*, 69(1), 21-51.

Wiggins, G., & McTighe, J. (1998). *Understanding by Design*. Upper Saddle River, NJ: Merrill Prentice Hall.

Summary for Website:

As part of a campus-wide academic calendar and curriculum revision, the Furman University chemistry department redesigned its introductory organic chemistry sequence. The traditional model, used at virtually every U.S. college and university, presents the canonical material over a two-course sequence. In contrast, the Furman chemistry department now offers a two-course sequence where the first course is an accelerated offering of the canonical material and the second course focuses on bio-organic chemistry. As greater than 75% of Furman's students in organic chemistry plan a career in the health professions, the enhanced biological emphasis in the new course sequence will give students a more relevant organic chemistry experience.

The major challenge facing such an approach is the lack of an appropriate textbook for the bio-organic chemistry course, which testifies to the originality of the course content. Dr. Brian Goess, along with Dr. Greg Springsteen, have used an approach to the construction of this course text that borrows from the successes of wikimedia as exemplified by Wikipedia. In short, students have been given the tools necessary to create, referee, and modify a course wiki, thus allowing students themselves to create an electronic text for the course based on the content

provided in lectures, literature readings, and a thorough problem set solution guide. Subsequent students in the course now use, augment and edit existing content. In this manner, each subsequent class has the responsibility of improving the online text, with the desired outcome being the most student-friendly text possible, since it will be created entirely by successive generations of students. Though wikimedia has been used successfully for many years in academic settings, to the best of their knowledge the use of wikimedia in the creation of an online course text for an original course is unprecedented.

This concept was beta tested in the Fall 2007 sections of organic chemistry, a course that uses an established text as a guide. Students were able to create, edit, and use content of their own creation on the wiki site, and end-of-term surveys indicated that many students enjoyed learning this new technology and found the information content helpful.

The student-created bio-organic e-textbook began with the first group of students to take the course in the Fall of 2008. The results were spectacular. Based on these results and the innovative approach used to generate them, Furman entered the project into the SC Innovision Awards competition, and it was awarded first place in the Technology in Education division.

Given the evolving nature of wikimedia, this project is a long-term commitment that will benefit from the contributions of thousands of students. A more immediate goal is the communication of project outcomes to colleagues at other institutions. This platform can be widely applied across any discipline, especially since an appealing feature of this project is that its final outcome, the wiki itself, can be accessed free of charge by anyone with Internet access and costs nothing to develop. Communication of the process through which such a project can be emulated on other campuses will take place on many levels. This strategy has been presented at the Lilly Conference on College and University Teaching in Greensboro, NC on February 20th. A report on the progress of this project will also be presented at an upcoming national meeting of the American Chemical Society (held twice yearly), which will provide a national stage for dissemination of the results of Furman's bio-organic e-textbook project.

Interview Questions

Disposition toward learning:

Outside of lecture and the textbook, did you ever try to find out more about a topic or concept covered in this course? What did you do? Walk me through the steps you took to learn more.

Existing Knowledge:

This course provides a number of opportunities to learn organic chemistry. How did you use each of the following to learn the material for the course: (1) lectures (2) textbook (3) classmates (4) wiki.

Was there ever a time when you had questions about whether something you read in the textbook or on the wiki was accurate? What was it? Can you explain your doubts? How did you gauge whether or not that idea/concept was accurate? How did the author/originator of that idea influence your decision?

Assumptions and beliefs:

Can you think of an example of time when a new idea/concept covered in the wiki caused you to rethink something that you thought was true? What was it? Can you explain it to me? How did this idea/concept go against or contradict what you had thought before? How do you think about this idea/concept now? Why do you believe that?

Research and Expansion of Knowledge:

Think back to a particular idea or concept that you learned in this class? Where did that idea come from? How did that idea come to be considered "true" or a "fact"? (Remind student that there are no right or wrong answers here) Explain to me how you think that process works? Is what is covered in the wiki true in the same way?

Communication:

Think back to your wiki writing assignment. What was it? I'd like to know about the steps you took, from start to finish, to write the entries? Where did you start? What did you do? Okay, the next step. Where did that happen? What did you do next? (continue until entire process is spelled out).

Possible follow-up questions:

1. (Intro Question) Tell me about the wiki project in your class. What was the purpose? How did you and your classmates use the wiki?
2. Describe the similarities and differences between the chemistry wiki, wikipedia, and the organic textbook.
3. Compare and contrast your perceptions of the process of writing a textbook, a wikipedia entry, and a chemistry wiki entry.
4. What guidelines do you follow when using someone else's words or ideas in your course work. Are the guidelines for using and citing someone else's ideas or work the same for a research paper, someone authoring a textbook, and a wiki?
5. What recommendations do you have for improving the utility of the wiki?
6. Compare and contrast your experience using the wiki and authoring content for the wiki.
7. How do you think the wiki should be graded? Should it be graded?
8. How did the wiki impact your understanding of organic chemistry?
9. Describe your classmates' impact on your learning of organic chemistry (follow-up specific to the wiki).