Using Wikis To Develop Collaborative Communities in an Environmental Chemistry Course

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Ⓢ *Supporting Information*

ABSTRACT: Group construction of wikis in an environmental chemistry course provided an effective framework for students to develop and to manage collaborative communities, characterized by interactive projects designed to deepen learning. A sequence of assignments facilitated improvement of the students' wiki construction and editing skills and these activities additionally spread the workload throughout the semester. Because the student groups selected their own topic for each assignment, the wikis provided some opportunity for students to personalize their course content. The ability to track multiple versions of the wiki allowed the instructor to observe the development of the final product and to attribute contributions to each individual student uniquely, a common concern regarding group work. Links created among the multiple wiki pages lent cohesion to the multiple assignments, created connections between groups, and unified the semester-long course content. The authors acknowledge the use of the graphic from http://www.clker.com/clipart-jigsaw-puzzle-4-pieces.html (accessed Sep 2014) for the table of contents image.

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The modern workplace requires collaborative skills that have not always been emphasized in the traditional classroom. Globalization of chemical research and the expansion of digital communications mean that a chemist may be working on a project that is shared with researchers in other laboratories or even in other countries. Thus, it is increasingly important for undergraduate students to learn how to participate in and ultimately how to manage collaborative efforts. Some instructors have responded to this challenge by using group work, team building, undergraduate research, or even cooperative learning in their classes. Others have assumed that these skills are best learned in graduate school or the industrial workplace. This paper describes the use of wikis to create student-led collaborative communities in an advanced-level undergraduate course.

The wiki format represents an excellent way for students to practice these collaborative skills. The online tools are readily available to almost all students, and a wiki system's change tracking utility maintains a history of revisions to make it easy for the instructor to identify each student's contribution for grading purposes. Articles by other educators have reported on the use of both Wikipedia and online Wiki sites to give students practice in working together and communicating with the general public. Specifically in chemistry environments, Evans and Moore have developed a wiki-based project for a second semester organic course where students chose a molecule and then created a Web page showing the mechanism of action of that molecule.[1] Elliott and Fraiman have created a Web site, Chem-Wiki, to allow organic students to collaborate outside of the laboratory,[2] and Wells and Clougherty have done a similar project with instrumental students.[3] Moy et al. have described a class project that enabled students in two different graduate-level chemistry courses to practice communicating science to a diverse audience by collaboratively editing an entry in Wikipedia.org.[4]

The University of Strathclyde at Glasgow, U.K. has developed a useful list of indicators related to the development of collaborative skills, including in their words, "The ability to work effectively with others on a common task; taking actions which respect the needs and contributions of others; contributing to and accepting the consensus; [and] negotiating a win-win solution to achieve the objectives of the team."[5] In addition, Pence and Pence[2] earlier have identified the need for students to learn how to create a personal information support system that will enable them to manage the information overload created by the combination of the social networks with traditional sources of information, such as books and monographs.[6] The goal of the exercise described in this current paper is to encourage students to develop the habits of social learning and professional interaction that will allow them not just to learn about a discipline but to be full participants in the professional interactions relevant to their discipline.

■ IMPLEMENTATION

At the time of the project, the two most commonly used freeware utilities for creating wikis were wikispaces.com and

pbwiki.com, although more recently, the Blackboard course management system has added tools for building wikis. Wikispaces was selected as the platform for this project because it was the most user-friendly option at the time, although the students' extended use of the program revealed several glitches with formatting and inability for multiple users to edit a document simultaneously and save all of the work. On a few occasions, the system froze and a student's work was lost, but developing strong habits of frequently saving work largely minimized this problem. The wikis were set up so that only invited users, i.e., the students in the course, were able to edit the documents while they were being created. The wiki project has been implemented twice in CH 519, Applied Environmental Chemistry, which enrolls about a dozen students and serves as an advanced elective for science majors at the University of Hartford and is a requirement for graduate environmental engineers. Early in the semester, for each project between 60 and 90 min of class time was scheduled in a computer lab to walk the students through the skills needed to build the wikis. In advance, the professor created the central page on Wikispaces, which eventually housed the table of contents and links to all of the wikis for the project. During the computer lab time, each student created an account on Wikispaces and was issued an invitation from the professor to become a contributor to the central page. The remainder of the computer lab time was devoted to details such as creating and linking new subpages, creating links to external content, pasting in images, and formatting.

A sequence of three group wiki assignments was used to replace an end-of-term paper done by each student in previous years. Building and editing wikis as a group facilitated exposure to this specific medium beyond the common use of Wikipedia for library research, and the multiple assignments, which distributed the workload throughout the semester was optimal for both the professor and the students. The use of small groups of students to create each wiki document not only provided an opportunity for students to participate in joint projects, but also introduced students to the group editing of an electronic document, which is becoming an increasingly common collaborative mode in the workplace.

Students were allowed to form their own three or four person groups, which remained intact throughout the semester. A grading rubric, included in the Supporting Information of this paper, was provided in advance so the students understood the expectations for their work.

A list of topic ideas, also included in the Supporting Information of this paper, was provided as a starting point for the wikis, although groups were also encouraged to select topics not on the list that might reflect their own backgrounds and interests. Topics were expected to relate to the lecture content in some way, but were also expected largely to cover material that could only be touched on superficially during class time such as issues with pharmaceuticals in the water supply, persistent organic pollutants, and biofuels. In the first year, students selected topics somewhat randomly, but in the second year, the topics corresponded more closely to the material being covered in class. For example, while water was the focus of class discussion, the four wiki topics selected were bottled water, water management, hydroelectric power, and green environmental remediation. The improved alignment of wiki material and class material resulted in better class discussions.

Creating a wiki provided the opportunity for students to investigate a topic in greater depth, and that larger knowledge base gave students a greater ability to contribute information during class discussions. By reviewing the references cited in the wikis, students were also encouraged to interact with electronic resources in a more thoughtful and critical manner. As with any new technology, repeated use is important for developing expertise, so for each sequential wiki assignment, the grading standards increased slightly as the students gained facility and confidence with the system. The due dates were conveniently spaced to correspond to the schedule of the three exams. Students were required to have rough content uploaded to the wikis by 2 weeks prior to the exam with the final edits due a week later. Additionally, it was acknowledged that unless prodded in some way the students would focus exclusively on their own projects and not explore their classmates' work. The exams were designed to counter this tendency. Each test included questions based on all of the wikis, but students were not allowed to answer questions based on their own work. Thus, knowledge of a minimum of one of the other wikis was required for a perfect score on the exam, and a second question could be answered for bonus points. Making the final deadline for each wiki a week prior to the exams allowed students to review content that was not in a state of flux.

To reach the quantity of work equivalent to a term paper, each student was expected to contribute the equivalent of three pages of text to each wiki assignment. In the first year the project was implemented, one student from each group was assigned to be the official editor for each wiki to ensure a consistent voice and the overall quality of the product. The responsibility rotated among the group members so that each student played the role at some point. Since the difficulty of that job was significantly influenced by the quality of the work contributed by the other students, that function was discontinued the second time the course was offered, and the editing responsibilities were shared among all the students on the team.

References were expected to be formatted consistently across all the entries by a group, and either the format from the *Journal of the American Chemical Society* or from Wikipedia was acceptable. Images were also expected to be labeled with a caption and with the URL to identify the original source.

■ ASSESSMENT

From an administrative perspective, both the students and the professor agreed that distributing the workload across the semester through the wikis was far more convenient than the term paper assignment that it replaced. The topics selected by the students also related to the class content more effectively than term papers, especially in the second year when the students tended to select topics that roughly corresponded to the lecture content for that third of the semester.

Grading fully integrated wikis in which all of the content was newly created and woven together by a team was far from trivial. In addition to evaluating the final wiki product as a static document, evaluation of each member's contributions required accessing the version history of the document which allowed different users to save drafts as they work. Two different versions of the document may be selected for comparison, in which case the changes made between one draft and another were highlighted. In this way, each member's contributions could be uniquely assigned, but it also required viewing multiple versions of a single document, which was time-consuming. The ability to identify group members who were not pulling their weight without relying on complaints from

Table 1. Results of Project Assessment Questions

	2009 Post	2010 Pre	2010 Post
Prior to this course, I had extensive experience with writing and creating wikis	1.46[a]	1.8	1.84
Having completed this course, I now have extensive experience with wikis	3.175[a]		3.77
Being able to select our own topics was a good idea	4.42		4.31
Having exam questions on the other wiki topics was an effective way of getting introduced to the other topics	4.08		4
The wikis were an effective way of incorporating outside topics into class.	4.16		4.46
I prefer to have my work spread out evenly over the semester/Having the wiki work spread out through the semester was better than one large assignment due at the end[b]		3.87	3.92
When I prepare written work, I edit it extensively before I turn it in/I edited the wiki work more than I usually edit my work[b]		3.87	3
I prefer to have a single large assignment due at the end of the semester/I would have preferred to write a term paper instead of doing the wikis[b]		2.4	2.54
I value the opportunity to learn new technology		4.13	4.07
I enjoy the opportunity to explore outside topics related to class in depth/Incorporating outside topics makes a course more interesting[b]		4.4	4.46
Methods of communication about the wikis:[c]	Spring		Fall
Face-to-Face, %	66.67		69.23
E-mail, %	83.33		15.38
Within the wiki, %	16.67		53.85
Text messages, %			30.77
Total students, N	12		13

[a]Normalized to 5-point scale. [b]The pre-project and post-project surveys had slightly different forms of these items with the pre-project statement being general (presented first in this cell) and the post-project statement referring directly to the wiki project (presented second in this cell). Both items were designed to address the same issue. [c]Students were asked to mark all of the communication methods they used, so the totals are not expected to add up to 100%.

fellow group members was invaluable, although without a strong contribution from all members, the wiki product often suffered in quality.

It was apparent that by having three sequenced assignments over the course of the semester, the quality of the offerings and the expertise of the students with handling the technology and content integration improved with each document. For example, the students taught themselves to set anchors, which are internal links which facilitate navigation within a single document. Anchors were used sparingly if at all on the first set of assignments, but became commonplace by the third set. Similarly, few illustrations were used in the first round of assignments, but the later wikis exhibited more pictures. The initial wikis were like silos, with each group working almost exclusively within their own wiki. As the students gained experience, they became more comfortable investigating the material in their classmates' wikis, and there were more links created among the wikis that were under construction at the same time. The history tracking option on wikispaces similarly indicated that more of the students were contributing in small ways to wikis outside of their core assignment. Even within a single group, the version histories indicated that in the first set of wikis, each student tended to focus predominantly on the section of the wiki that he or she had contributed, whereas by the third assignment, the students were editing throughout the document.

The project was evaluated by using questionnaires containing a combination of free response questions and questions allowing for students to use a five point Likert scale to indicate the degree to which they agreed or disagreed with a statement. A score of 5 indicated strong agreement with a statement, whereas a score of 1 indicated strong disagreement. The questionnaires were administered after the 2009 project, and both before and after the 2010 project. The results of the numerical responses are presented below in Table 1.

■ DISCUSSION

The numerical data from the anonymous student surveys indicated that the students reported little experience with wikis prior to the course. The 2010 class had consistent averages of 1.8 and 1.84, indicating disagreement with the statement "Prior to this course, I had extensive experience with writing and creating wikis," when asked both before and after the project. Both the 2009 and 2010 classes indicated a significant growth in their expertise at the end of the projects with averages of 3.18 and 3.77 signifying agreement with the statement "Having completed this course, I now have extensive experience with wikis." They agreed or strongly agreed that selecting their own topics was beneficial and that the project was an effective strategy for including outside topics in the course. There was strong agreement that the inclusion of outside topics made the class more interesting. Spreading the workload throughout the semester rather than having a term paper or other large assignment due at the end of the semester was viewed favorably, and the students also indicated that they valued the opportunity to learn new technology.

Free response comments on the evaluations from the students were overwhelmingly favorable about learning how to create a wiki and by extension to understand how Wikipedia is created and is modified. Although many students did not immediately anticipate creating their own wikis in the future, several individuals commented on the potential for using wikis to coordinate among different groups to improve processes and standards.

This project developed several skills that should be useful to students in their later careers. Choosing a topic that was of personal interest gave them ownership of a topic they had selected rather than just following the assigned topics from the instructor's syllabus. Using the Wiki as a forum for discussion and exploration encouraged the type of group work that is often necessary for research. Broad participation was encouraged by the knowledge that each student's efforts

would be graded individually, and the shared workspace provided a structure that encouraged the students to interact and explore the framework they were creating.

The students indicated in their comments that they appreciated the freedom to select their own topics and explore material using their own structure. Being able to explore three topics over the semester rather than just one topic in a single term paper was also identified as a benefit. In spite of a list of nearly 30 topics provided as part of the assignment and the ability to propose their own topics, the second class made a number of comments on their evaluations requesting a longer list of topic options.

An interesting shift in the communication methods among the collaborative communities occurred in the 18 months between the two projects. In the first class, the students indicated that they used email extensively to coordinate their contributions to the wikis with 83% of the students indicating that they use this method. In the second class, email interactions fell to just 15% of the interactions whereas there was a significant increase in the use of text messages for updates. The version histories of the wikis revealed at least part of where these communications had shifted. Several of the groups who worked on the second project developed great facility with using the wikis themselves as a format for conversations, by leaving notes and responses for each other in the early versions of the documents.

The comments also mentioned the usual dislike students have for group work as well as the challenges and frustrations among students when all members of a group were not participating equally in volume or quality, but they appreciated that the wiki format allowed for individual rather than group grades to be determined. The students also found that the wiki format was an advantage for integrating the contributions of all group members, as long as those components were added in a timely manner.

In the second year, the decision had to be made whether to have the students in the new class start with a clean slate or use the previous year's work as a basis. On the basis of the feedback from the students in the first class, the second group of students was allowed to create their own wikis from the start without reference to the earlier work. Because the groups did not build off each other, and because the students generally focused on breadth instead of depth, it is unlikely that the wikis of the type the students prefer will ever be a valid substitution for a textbook. Indeed, because the wikis focus on auxiliary topics rather than core material, there will always be some need for a reliable resource for foundational content.

Ultimately, the only negative aspect of the project for the students and the professor was the wiki platform itself, which suffered from intermittent bugs and freezes. These issues were regarded as a nuisance rather than a fatal flaw, and improvements in wiki utilities will potentially eliminate this source of frustration.

■ CONCLUSIONS

Engaging students as full participants in their learning is an important component in creating collaborative learning communities, and the creation of wikis is an important alternative that can be added to the toolbox that already contains strategies such as guided inquiry and peer engagement. Through establishing collaborative communities, students explore content that bridges classroom material with their own interests, all of which is grounded in a conversation with their peers. This process not only enhances their experiences in a single course, but also contributes to a stronger preparation for their future work in collaborative environments.

■ ASSOCIATED CONTENT

Ⓢ Supporting Information

A copy of the list of possible wiki topics as well as the grading guidelines. This material is available via the Internet at http://pubs.acs.org.

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Notes

The authors declare no competing financial interest.

■ ACKNOWLEDGMENTS

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