Curricular Enhancements to the First-Semester Organic Chemistry Sequence Using Online Tools

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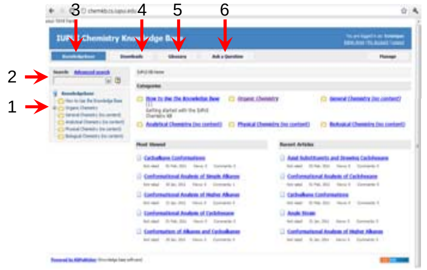
Knowledge Base Development for the 1st Semester Organic Lecture



1 – Folder tree allows users to browse for logically sorted articles/content in a more traditional "textbook" style.

2 - Search engine for finding specific articles by topical searches.

3 – Knowledge base button returns users to the home page.

4 – Downloads button takes users to multimedia content such as video/audio that provide interactive problems or recorded lectures on specific topics.

5 – Glossary link provides students access to the online glossary.

6 - "Ask a Question" function allows students to submit a question when the posted articles fall short. Answers can be incorporated into a previously posted article or published in a separate article.

1 – The folder tree in use.

2 – Words in red can be left-clicked to show a pop-up text box that provides a glossary definition.

3 – Prev and Next buttons allow users to navigate from one article to the next in a category without going back to the folder tree, similar to reading through a textbook.

4 – Article rating system allows users to voice their opinion on the relevancy/helpfulness of the article. These ratings are compiled for all users/administrators to provide the articles' "helpfulness."

5 – Add a comment button gives the user additional feedback capability to post a specific comment or idea about the article, which should enhance site content.

Introduction

Herein, we report the novel application of knowledge base (KB) software in the undergraduate organic lecture. As the IUPUI Chemistry KB is still in development, we will primarily focus on its potential utility in an educational setting. A KB is a term used to describe a collection of online material that is organized and retrievable. When utilizing a tool such as this, one being newly used in chemistry education, it is often useful to explore how it relates to previously tested ideas and how it could improve upon them. Several reported ideas that utilize online knowledge to aid in student learning include online blogs, online textbooks, and student-developed wiki sites.

Educational Blogs vs. KB

Blogs are one of the earliest online knowledge formats to be incorporated into educational environments, diverging from the standard textbook and lecture format. Blog-based education allowed a transition from a read-only information system to a dynamic read-write multimedia environment.[1] Blogging as an educational tool, especially in the sciences, certainly has some disadvantages. Blog topics tend to be written solely on immediate knowledge and people tend to neglect further development into an idea or topic; therefore postings tend to be more unreliable and opinion-based.[1] While blogging boasts a mild learning curve for participation, another glaring disadvantage is that it tends to lack overall organization and clarity. While blogging may have its disadvantages, it still stands out as a progenitor of the online information environment.

Online Textbooks vs. KB

Online textbooks have advantages over their print counterparts in that they are cheaper, more cost effective, more functional, and have the added benefit of saving paper.[9] The downside to online textbooks, however, lies in the fact that extended periods of time are required for reading material on a computer screen, which can prove to be tiring on one's eyes. This, studies have shown, leads many users to simply print out material provided in online textbooks thus negating their paper-saving benefits.[9] However, the articles in the KB are specifically written to be short and concise without sacrificing content. We believe it is evident in literature that online textbooks provide a superior platform for learning dynamic concepts of science and chemistry, for instance NMR spectroscopy.[11] Our KB bridges this gap between print and online textbooks in a far more accessible and concise platform that infuses effectively written articles with multimedia content which further expands the students' retention of material.

Wiki's vs. KB

A "wiki" refers to a web page which can be changed and altered by the very people viewing it. This inevitably leads to the major disadvantage of the wiki format, susceptibility to false and mis-information. In a case study done on Wikipedia, one of the largest online wiki's which receives over 60 million hits per day, two experts found that 13% of the articles contained errors.[3] This enormous percentage of errors stems from the idea that anyone can add content or edit existing content. Ideally over time errors will fix themselves. However, if a large site like Wikipedia contains an error rate of 13%, one must question whether a smaller student-run wiki is practical. As a wiki's credibility is called into question, it is often recommended to have an information guardian to ensure accurate content. However, this process abandons the true wiki format and enters the realm of the current KB model by significantly limiting students' ability to create and edit content. Therefore in our KB, content creation is left primarily up to experts (faculty and TA's).

KB as Social Software

A major benefit of wiki's provides students the opportunity to become co-creators of the material they are learning.[4] However wiki's and KB's alike are both forms of social software which, with certain adaptations, can provide for increased student performance and involvement.[5] Social software allows the users to evaluate site content, vote on content, and provide criteria and ideas for later improvements.[6] So, users in our KB are allowed and encouraged to comment on postings and rate them for later improvement by faculty. We believe the defining aspect of student involvement in this knowledge base comes from the "Ask a Question" function, which allows the student to guide the development of new postings based on their questions. This in turn can lead to an idea that has found much success in other wiki course sites.[7] However, research has shown that a major limitation of most wiki's (to be edited by one person at a time) can lead to a backlog of information, as well as student frustrations.[8] It is in our opinion that development of content by students alone would be slow and lead to a general lack of confidence in the content of the site, especially in more advanced courses.

Advantages of the KB

A primary advantage of the KB is that experts generate site content. This not only increases credibility and confidence in the site, but also permits for the KB to be a collection of ideas from multiple experts. These variances in information and presentation of ideas could enhance student learning potential by allowing the students to take advantage of whatever information style best suits them. Also, by using the "Ask a Question" function, students can ask questions that normally would be saved for office hours or recitation classes. When a faculty member posts an answer on the site, it allows both the student who asked the question and their peers, who might have had a similar question, to view the solution. This allows knowledge transferred in office hours or recitations to be saved indefinitely. This idea is currently being developed to further possibly incorporate faculty-generated multimedia postings from lecture or recitations, such as video explanations and lecture audio recordings. As we continue to move forward in a technology-driven society, students will continue to crave multimedia study aids.[9] From a functionality standpoint, research and case studies have shown that a potential downfall to any web-based social software is functionality and ease of use.[8] Therefore, we are making every effort available to ensure maximum KB functionality.

Using Google Analytics to Monitor the KB

The KB utilizes Google analytics to monitor use of individual articles, multimedia content, and the site as a whole. Google analytics offers site administrators objective multi-faceted statistical data in a visual format that allows them to follow the interactions between the students and the KB.[10] The tracking information is available nearly instantaneously, with at most a two hour delay. When coupled with exam and quiz scores this data could provide concrete evidence as to the benefits of the KB and cyberlearning.

The functionality and benefits of the Google analytics software:
• Track articles viewed by users
• Track which users are using which articles
• View log-on duration of users
• View time duration that articles are viewed as a whole and by individual users

Curricular Enhancements to the 1st Semester Organic Laboratory

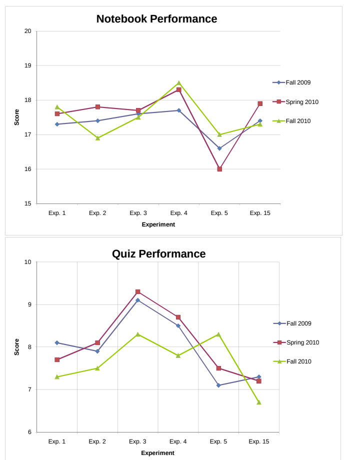
To date, several innovations in teaching laboratory methodology have been introduced to combat the strictly expository, "cookbook" approach, including inquiry, discovery, and problem-based instruction.[1-4] In order to properly investigate these instruction models, taxonomy has been developed to provide a means for empirical discussion. Laboratory instruction can be qualitatively considered through three variables: *outcome*, *approach*, and *procedure* (Figure 1).[2] Outcomes may be predetermined or undetermined (unknown) with respect to final results, whereas experimental approach is differentiated by deductive and inductive proposals. Finally, the procedure can be student-generated, which is typical of inquiry instruction, or provided by the instructor, which is traditional of the expository model of laboratory instruction.

Figure 1: Comparison of Laboratory Instruction Models[2]

	Outcome	Approach	Procedure
Expository	Predetermined	Deductive	Given
Inquiry	Undetermined	Inductive	Student generated
Discovery	Predetermined	Inductive	Given
Problem-based	Predetermined	Deductive	Student generated

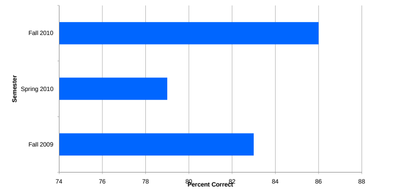
Here, we present how multiple changes in organic laboratory curricula over consecutive semesters affect student perceptions and academic performance. Not only have multiple instruction methodologies been implemented, but extensive multimedia and online resources have been created in place of materials commonly covered by a professor or teaching assistant. Throughout the curricular changes, student performance as displayed in laboratory quizzes and exams has been recorded, focus group analysis has been performed, and a survey has been designed to consider the student's perceptions of their laboratory education. Some of this data, included in figures below, will allow for a brief comparison of our curricular changes.

Figure 2: Student Performance vs. Laboratory Progress



Traditionally (**Fall 2009 and before**), 3h laboratory sessions were supplemented with one weekly lecture-style 1h15m recitation in which TA's would lecture and administer quizzes. This strictly lecture approach limited student involvement in the classroom and laboratory, and instruction was reliant upon the TA's understanding and presentation. Most laboratory experiments were either expository or weakly inquiry-driven and no additional instruction was provided outside of in-class lectures and the course text. Experimental techniques were demonstrated through informal instruction during experimentation and student academic performance was evaluated through notebook grades, quizzes, and a cumulative final (Figures 2 & 3).

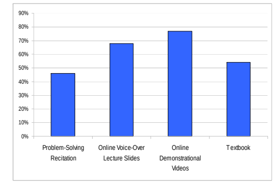
Figure 3: Average Final Examination Scores per Semester



In order to combat a solely expository approach, the **Spring 2010** curriculum was modified by removing in-class recitation lecture sessions and implementing an inquiry-driven laboratory to demonstrate the principles of nucleophilic substitution reactions. All material that was typically covered by teaching assistants was provided through instructor-created narrated .pdf lectures and experimental techniques were explained via informal videos posted on YouTube. In this model, students were responsible for viewing the online content in order to prepare for evaluative tools: notebook grades, quizzes, and the final examination at the end of the semester.

In removing the recitation class time, student focus groups noted a lack of holistic instruction and the ability to ask questions when solving problems. Thus an integration of online resources and class room time was provided in the **Fall 2010** with an emphasis on group problem-solving. Weekly recitation time focused on providing problem-based discussions exploring common chemical problems based on theoretical concepts being studied within the laboratory. Online lectures and instructional YouTube videos were still provided and utilization was encouraged for laboratory success. The benefit of group problem-solving techniques was especially displayed in the inquiry-driven laboratory, by reinforcing interpersonal communication and the ability to solve chemical problems without expository instruction.

Figure 4: % of Students that Perceived a Learning Tool Crucial to the Course



Among the information collected from survey data and focus groups, was the perceived importance of learning tools in the laboratory (Figure 4). From this data, it was evident that students favored the shorter, demonstrational YouTube videos compared to voice-over lecture slides. Interestingly, students perceived the group problem-solving recitations to be of least importance. Anecdotally, we believe students are still most "comfortable" in a lecture format, whether in-class or online. We also believe it crucial to continue to develop ways of involving students in active learning processes.

Conclusion

In conclusion, several curricular changes were introduced within the 1st semester organic laboratory in order to utilize various instructional approaches to increase student learning outcomes. Overall, cumulative final grades rose throughout the curricular changes, suggesting that problem-based and group learning strategies may increase retention and long-term conceptual understanding. Conversely, quiz performance was noticeably low during the implementation of PBL recitation sessions, which may suggest a decrease in learning efficiency/motivation from online lectures, though other course modifications might have led to this drop. Notebook performance can be effectively viewed as student motivation and organization within the laboratory, which was slightly depressed during the Fall of 2010. One could hypothesize that total work-load (from increased time to view online lectures) combined with classroom attendance requirements correlates with a decrease in student time investment in the course. In contrast, during the Spring 2010, the lack of additional meeting time outside the wet laboratory settings led to a decrease in retention as final grades were notably affected. Although a perfect approach towards laboratory instruction has not been developed, future research avenues exist to continue to reinvent chemical pedagogy.

Acknowledgements

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