The Evolution of a Web-Based Chemistry Learning Site

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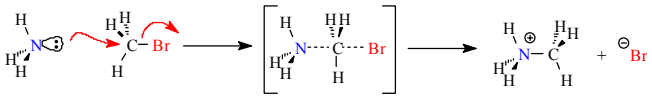
Abstract: This paper discusses some of the various means of presenting Web-based chemistry tutorials and the relative effectiveness of each method. These methods utilize animated images, interactive question and answer tutorials, images with embedded links, and interactive multiple-choice questions with answers that attempt to explain why wrong selections are not correct.

[*]Introduction

The World Wide Web offers a wonderful opportunity to present difficult subjects in an interactive manner similar to the approach that teachers use when presenting the same material in a classroom setting. It also offers some distinct advantages over traditional presentations in that any given tutorial can be rerun until the student learns the concept. The goal of any Web-based learning aid should be to allow a student to learn interactively, rather than to learn passively by reading the material. This is not only a better learning experience but it is also much more enjoyable for the student.

Discussion

Animations. The development of animated GIF images permits the demonstration of organic reaction mechanisms in a dynamic fashion using classical structural formulas. For example, the following S_N2 mechanism is more understandable when viewed as an animation. http://chem.boisestate.edu/~rcbanks/organic/ammoniasn2.gif



Animated GIF images can also be used to demonstrate fundamental concepts in inorganic chemistry, such as the filling of atomic orbitals. Orbital box diagrams are classically used to illustrate this process, but only one or two examples are given in most texts or lectures due to space and time constraints. An animation can illustrate this process for many elements and can be viewed repeatedly by students.

http://chem.boisestate.edu/~rcbanks/inorganic/atomic%20structure/atomicstructure_h.htm

The drawing of electron-dot formulas is an excellent example of where animation is pedagogically better than the classroom experience. We present this concept as a step-by-step process in lecture, but when we are done, the result is the completed formula with none of the individual steps shown. This is precisely what the students have in their notes and is of little use if they do not remember the process used in developing the formula. The animation demonstrates all of the individual steps and can be repeated as often as desired. http://chem.boisestate.edu/~rcbanks/inorganic/ethene.gif

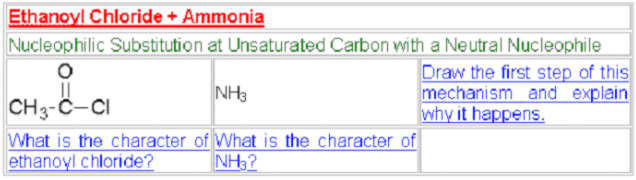
Animated GIF images do present a distinct set of problems. Some students feel they run too rapidly while other students feel they run too slowly. You can set the time between frames and even vary the time between different frames but you will never have the timing at the best speed for everyone. The animations can be stopped so that a student can study an individual frame but they will always start back at the beginning when the refresh button is pressed. Most of these animations have been converted to AVI movies, which can be paused and restarted but, unless a student has a very fast Internet connection, the download time is prohibitive. Lastly, it is important to keep the nonmoving part of the image stationary in the different frames or it vibrates in a distracting manner.

Question-Answer Tutorials

Another approach that was pursued was to emulate lectures more closely and to develop tutorials presented in a question and answer (QA) format. This format is very beneficial to students because they can answer the questions, click on the link, and immediately see the correct response. Almost everything presented in lecture can be emulated with this type of tutorial.

The first QA tutorials that were developed were tutorials for organic reaction mechanisms. These QA tutorials allow questions to be asked of every detail of a reaction mechanism. An example of this type of tutorial is the reaction of an acid halide with ammonia. http://chem.boisestate.edu/~rcbanks/organic/ethanoylchloride+NH3tutorial.htm

The following illustration is a screen shot of the first page of this tutorial.



Question and answer tutorials were developed for several topics:

organic reaction mechanisms http://chem.boisestate.edu/~rcbanks/organic/mechanisms.html

[*] Presented at the ACS Division of Chemical Education sponsored symposium on web-assisted learning in chemistry at its 221st national meeting in San Diego, CA April 1–5, 2001.

organic synthesis problems http://chem.boisestate.edu/~rcbanks/organic/synthesis/synthesis.html

electron-dot formulas http://chem.boisestate.edu/~rcbanks/inorganic/electron-dot.htm

balancing chemical equations http://chem.boisestate.edu/~rcbanks/inorganic/balancing.html

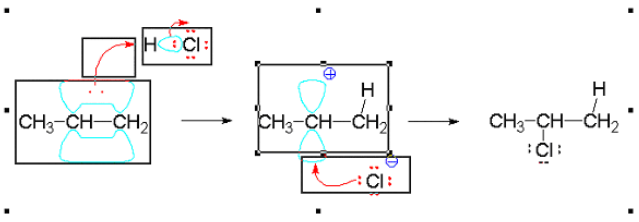
problems in chemistry http://chem.boisestate.edu/~rcbanks/inorganic/collegechemistryproblems1.htm

Images with Embedded Links

Images with embedded links (hotspots) are not quite as pedagogically useful as the question and answer tutorial but are much easier to construct. They are constructed by first creating a GIF image in a document. Then (using Microsoft FrontPage) the image is selected and areas are created within the image with links to other HTML pages. These links explain the conceptual basis for each part of the mechanism.

The following image is a screen shot of one of these documents, opened in FrontPage Editor, which demonstrates how the hotspots were placed on the GIF image. http://chem.boisestate.edu/~rcbanks/organic/Propene+HCl%20reaction.htm

Reaction of Propene with HCl



Multiple-Choice Questions with Answers

Multiple-choice question tutorials were also developed. Most of the practice questions on the Web are based on Java script. The student answers a series of questions and then checks for the correct responses. This format does not allow for instant feedback, and just showing the correct answer does not help the students understand why they missed the question. This can be very frustrating to students who, instead of trying to understand why they were wrong, simply memorize the correct answer to a specific question and subsequently cannot answer a similar type of question on an exam.

During the development of this phase of the project, it seemed that it would be very easy to transfer questions that had been created over the years to HTML format and create links to the answers. The work involved in creating all the other tutorials pales in comparison to creating these tutorials. Explaining why the distracting wrong answers were incorrect takes an immense amount of time. It is necessary to visualize what the students were thinking when they answered the question and to explain what they should have thought about the problem. The goal is to encourage the student to rethink the problem and select another answer. It is important to use hints to get them on the right path, rather than just presenting them with the correct answer.

It is essential to refrain from being facetious in your responses, because students will interpret this as ridicule and quit using the tutorials. This tutorial uses a series of faces ranging from a smiley face, for the correct response; a pensive look; a groan; and finally, for the worst answer, a crying face. The students enjoy the faces, and the point gets across in a humorous fashion that is not viewed as sarcastic.

These multiple-choice question tutorials can be accessed at the following links:

Organic Chemistry http://chem.boisestate.edu/~rcbanks/organic/mc/mcquestions317.htm

College Chemistry http://chem.boisestate.edu/~rcbanks/inorganic/mc111/mcquestions111.htm

Essentials of Chemistry http://chem.boisestate.edu/~rcbanks/inorganic/mc101/mcquestions101.htm

Conclusions

It is important that the download time for each HTML page on a normal modem connection is no more than 40 seconds. Students have little patience for slow-loading pages. Web pages utilizing frames reduce the effectiveness of the tutorials by reducing the effective size of the page and increasing load times. The pages should present the material in a clear, easy to use format.

Surveys of the students enrolled in Organic Chemistry, College Chemistry, and Essentials of Chemistry at Boise State University have shown an overwhelming preference for the question and answer and the multiple-choice question tutorials. The question and answer tutorials were top-rated. The multiple-choice questions were a close second, and the better students always looked at the wrong answers to check on their logic in solving the problems. The animations are very useful and probably more useful than the students rated them. It is probably not worth the effort to make images with embedded links as the students did not care for these as much as the other tutorials. These tutorials need to be modified to have questions written directly on the image by each hotspot.

About 90% of the students in Organic Chemistry regularly used the tutorials. A little over 80% of the College Chemistry students used the tutorials and this number dropped to 70% for the Essentials of Chemistry students. The comments from the students who used the site have been very favorable and encouraging.