Chemistry is in the News. 1. Taxonomy and Implementation of News Media Based Authentic Learning Activities.

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¶ Part 1 in a series. For part 2, see reference (1).

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Abstract. A brief history is given of appraoches that aim at achieving a connectedness of the content of organic chemistry courses to real world issues. Recently, such approaches rely more and more on online media resources, the tools of the internet and the world wide web. We propose a six-level taxonomy of "News Media Based Authentic Learning Activities" to provide a conceptual framework for the description and discussion of such approaches. The "Chemistry is in the News" project was designed to allow students to draw explicit connections between course content and real world issues in ways that engage the students in a full range of cognitive skills. The implemention and integration of "Chemistry is in the News" activities in two large lecture Organic Chemistry courses is described. The activities consisted in the study, creation, and peer review of "news items" by student collaborative groups. A "news items" consists in an authentic news article with editorial comments and questions.

Introduction

The importance of students constructing the connection between the content of chemistry courses and real world issues and problems has been emphasized by educators, researchers and administrators (1,2,3,4). Constructing the connections is important for purely pedagogical reasons as well as with a view to sociological and political consequences (5,6). The higher goal of chemistry education is thus well defined and the significance and importance of achieving these goals have been well justified and they are widely accepted. The grand challenge at this time concerns the design, the implementation and the assessment of teaching methods that accomplish these ambitious goals in a systematic fashion. These methods should be fit for widespread adoption so as to serve as teaching tools that can affect systemic change.

This article is the first of a pair of articles on the "Chemistry is in the News" project. In the present article, we first review traditional and emerging strategies for the integration of real world content into organic chemistry courses. Many of these strategies utilize newspaper articles to define the real world issue and more recently online news media play an increasingly significant role. Next, we propose a taxonomy of "News Media Based Authentic Learning Activities" to provide a conceptual framework for the discussion of the various approaches and the evaluation of their educational benefits. In the third section, we describe the implementation of such activities within a large lecture Organic Chemistry course taught at the University of Missouri–Columbia. The activities consisted in the study, creation, and peer review of "news items" by student collaborative groups. A "news item" consists in an actual news article with editorial comments and questions. The description of the implementation focuses on organizational issues and on the integration of the teaching materials into the course. In the second (1), we discuss the philosophical and pedagogical aspects of the learning activities in more detail and with a view to the psychology of teaching and learning. It is the main purpose of that second article to discuss the results of an assessment of the first-generation implementaion of the activities and to derive suggestions for improvments in future implementations.

Brief History of News Media Based Authentic Learning Activities

Complexity of the "Web of Chemistry." Understanding organic chemistry requires extensive knowledge of sets of properties of many molecules and of the many reactions in which these molecules can participate. Students of organic chemistry are required to constantly review what has already been learned and to construct the "web of chemistry" connecting all of these pieces in the many possible ways. It is for this reason that organic chemistry is "difficult"; understanding organic chemistry requires of its students a high capacity for knowledge and comprehension. Organic chemistry is a requirement for a broad spectrum of students and chemistry majors usually present only a small minority of the audience. The majority of students take organic chemistry because it is required in their majors and the intrinsic interest and motivation often is low. Teachers of organic chemistry thus are faced with a fundamental dichotomy.

Most modern textbooks of organic chemistry employ a combination of the functional group / mechanistic approach. This approach offers many advantages but many equally interesting connections remain neglected. The development of synthesis skills, for example, would require more focus on disconnections and would benefit from a presentation based on the formations of various types of bonds and functional group modifications. One can make the same argument for many other aspects of chemistry. And one of these aspects concerns "connectedness to real world issues." One thus is presented with a choice. It is one option to make the "connectedness to real world issues" the key organizational guide and this philosophy found its manifestation in the "Chemistry in Context" project (7) and a few textbooks (8,9) for non-science majors. The alternative consists in the development of effective strategies to embed the goal of "connectedness to real world issues" within the framework of the functional group / mechanistic approach.

"Chemistry in Context" and "Boxed Essay" Approaches. "Chemistry in Context" is a project of the American Chemical Society that has led to the publication of an innovative textbook for non-science majors that aims at establishing chemical principles within a contextual framework of significant societal-technologial issues (7). Each chapter addresses an important societal issue (energy, food, drugs, ...) and the material is presented to the students in a way that stresses the direct

effects of chemistry on their lives. The approach develops chemical knowledge on a need–to–know basis so that students can more fully appreciate its contextual relationship of the topics.

The presentation of chemistry in the context of significant societal-technologial issues presents a shared goal of the education of non-science and science majors alike. However, the education of science majors and especially of majors in chemistry-related fields foremost requires a systematic study of chemical principles. This is particularly true for chemistry since the majority of chemistry and chemistry-related majors will be employed in research settings. Given these priorities, it appears reasonable that the choice between the "Chemistry in Context" approach and the "Functional Group / Mechanisic Approach" is decided in favor of the latter for chemistry majors and possibly also for science majors. With most textbooks following the "Functional Group / Mechanistic Approach", a number of teaching strategies have been used to help students make the connection between the abstract chemical principles they are learning and the real world. Many textbooks highlight actual problems related to each section of the text. Strategies such as these enhance the interest level of the course content and they help students see connections.

The "boxed materials" in Bruice's "Organic Chemistry" text bring life to the topics discussed (10). The books by Wade (11) and by Vollhard and Schore (12) both feature many photos of everyday life items and Vollhard uses chapter introductions to relate the chapter's material to everyday experience. Carey employs "boxed essays" (13) and some of these focus on societal implications. McMurry (14) provides "interludes" to enliven and reinforce the materials presented. Solomons and Fryhle (15) employ "The Chemistry of ..." essays to highlight special topics and every chapter begins, traditionally, with a vignette that shows how the chapter's subject matter is related to 'real-world' applications. The text by Brown and Foote (16) provides "Chemistry in Action Boxes" to illustrate everyday applications of organic chemistry. The text by Hornback (17) is the most extreme approach to date toward teaching organic chemistry by way of case studies. The "elaborations" in this text indicate a pronounced move away from the traditional approach while increasingly embracing the principles of the "Chemistry in Context" approach.

Newspapers are the Mirrors of Society. The topics of the "boxed essays" all have made headlines in the past and many of the topics continue to be of genuine interest to society. It is therefore only natural that one goes one step further and employs topics of societal relevance that are currently in the headlines. For several years, the *New York Times* has been producing "Chemistry: Themes of the Times." This mini-newspaper features selected articles of the *New York Times* science pages, it is updated annually and available free of charge to adopters of Prentice Hall textbooks. Simon & Schuster's College NewsLink is a unique educational online news service (18). Instructors and students can access articles from leading newspapers from around the world. The articles are organized by academic disciplines and chosen for their educational relevance. *Sigma Xi*, The Scientific Research Society, provides a free daily e-mail update on science news from US newspapers (19). While it is the primary purpose of this Media Resource Service "to put journalists in touch with reputable sources of scientific information," this "Science in the News" service presents a useful teaching tool. The college edition of INFOTRAC is an online service that provides internet access to complete articles from over 600 publications. This service is available free of charge with the adoption of Wadsworth or Brooks/Cole textbooks (20) and these include the texts by Hornback (17), McMurry (14) and Fessenden & Fessenden (21). INFOTRAC allows for access to current newsmedia, popular science publications and also to more specialized journals. University libraries frequently have site licences for the web editions of many scientific journals and it is reasonable to expect that this access will become more widely available in future.

Taxonomy of News Media Based Authentic Learning Activities

Drawing connections between chemistry and the real world serves both as an end of chemical education and as a means to facilitate learning. To employ current articles from newspapers and online news media presents a natural extension of the traditional "boxed essay" approaches. *Newspapers are the mirrors of society and newspaper articles therefore are the sources which allow one to construct the important relations between society and chemistry.* One significant difficulty with this approach, however, is that without some guidance, students initially

may be unable to draw connections between the abstract chemical principles they are learning and the real world topics discussed in the articles (1). Ideally, one wants to engage the students in a full range of cognitive skills that range from the acquisition of knowledge and the development of comprehension to application, analysis, synthesis and evaluation (22). Hence, there exists a clear need to develop strategies to integrate the media resources into science courses in a way that enhances the interest in the course content and helps students to see the connections.

In this context, we suggest a taxonomy of "news media based authentic learning activities" (Table 1) to provide a conceptual framework for the description and discussion of such approaches. Next, we describe the "Chemistry is in the News" project in which students engage in Level-1 through Level-4 activities. The activities, in principle, can be carried out by individual students or by collaborative student groups. We favor the group approach because it provides many educational benefits (1,23).

Level-1 Activities: Reading the News. Students have access to printed or online articles. The news articles are provided with minimal guidance and without any well-defined approach to connect the content of the news articles to course content. All of the media services discussed above qualify as Level-1 activities. To really meet pedagogical needs and to provide true scientific literacy, students must do something with the connections (1). The students need a conceptual understanding of the science content and they also need practice in evaluation of evidence. These goals are addressed in the higher levels of the news media based authentic learning activities.

Level-2 Activities: Working with News Items. Level-2 addresses two fundamental needs, namely, the need for a well-defined approach to connect the content of the news article to the course content and the need that students must <u>do</u> something with the connections. At this level, an article is presented as an integral part of a "news item." A "news item" consists of an actual and recent online news article, editorial comments and a number of questions. The editorial comments serve to clarify the issues and facts, to objectively delineate the connection between the news and chemistry, and to provide additional information and background material. The editorial comments include links to high-quality sites and they frequently include animations, graphics and movies. The

addition of questions to a "news item" makes the learning activity a more active one. Well selected questions can provoke critical thinking about the presented material and its societal, economic, and environmental consequences, and answering the questions also requires a more in-depth analysis and evaluation of the material. Level-2 "news items" are created by the instructor thereby assuring both high quality of the educational material as well as its most appropriate placement in the course. The intellectual goals of Level-2 activities focus primarily on knowledge and comprehension.

Level-3 Activities: Creating News Items. At Level-3, the student becomes the *creator* of a news item. It is one thing to bring to the attention of the students the cogent chemistry issues of our times. And it is even better if the students find out about these issues and collaborate to *create* news items. The first of three major novelties at Level-3 consists in the identification and selection of news media resources and the acquisition of skills to search for articles in these media resources. This focus on the source of information and on the access to that source is a truly eye-opening experience for the students! Some guidance needs to be provided as to how to select among the vast numbers of available online news media from around the world and as to how to select articles as candidates for the news items. The second novelty at this level is even more important: At Level-3 the students must *make* — not just *recognize* — connections between course material and real world issues. It is more than likely that the final selection of an article for a news item is made after a number of candidates have been considered. Hence, Level-3 acivities leads to the making of multiple connections and they require evaluation and judgement in the selection of the best source material for the news item that is to be created. The third novelty at this level is the creative act of writing a news item for one's peers. Writing a news item requires more comprehension and understanding than reading an existing news item. The application of knowledge, analysis of original sources, and the synthesis of a cohesive news item are the intellectual goals at Level-3.

Level-4 Activities: Peer Review of Student-Created News Items. At Level-4 the students' projects are evaluated by peer review rather than by instructor review. Peer assessment has long been used in writing courses and is now emerging as a means of assessing student work in a variety of fields (24,25,26,27). Research has shown that peer evaluation supports collaborative group

work in general and, in writing assignments in particular, it supports a shift in students' perspective from writing for the teacher to writing for their peers and, ultimately, for a larger audience. Since these project reports are published online, it is appropriate that they are reviewed by their peers. Peer review is another form of communication (28,29) and trains an essential aspect of the scientific process. Henderleiter and Pringle (30) recently stressed that students must learn skills that go beyond the mechanics of chemistry: "A chemist must be able to communicate with other chemists and nonchemists, work a member of a team, evaluate data, and make decisions and recommendations based on data collected." At this level, the students realize that reasonable people might look at the same data (e.g. food safety, drug approval, …) and for legitimate reasons arrive at different conclusions. Students learn that the rigor of scientific analysis is diminished when applied to complex real-world situations. Absolute judgement disappears and students learn how to deal with imperfect options and they start to appreciate the idea of the *Precautionary Principle* (31).

Level-5 Activities: External Peer Review of News Items. Level-5 presents the step from internal to external peer review. External peer review requires a situation where the same creative learning activities are being pursued concurrently in two similar courses at different universities and the students of the two courses review each others projects. Relatively little has been done in terms of using the internet for such student interactions across institutions. Some authors discussed the potential use of the cooperation via the internet to solve chemistry problems and provide feed-back online (32). Aside from the additional management effort, Level-4 and Level-5 activities differ significantly. Pedagogically important are the facts that the evaluators no longer know the evaluees, that they have been instructed in different places in slightly different ways and, most of all, that their backgrounds and experiences may be greatly different. Indeed, the students would benefit the most if some of the views held by the different groups are in conflict. Imagine news items on "nicotine and smoking" created and evaluated at universities in Minnesota and South Carolina; image news items on "acid rain" created and evaluated at universities in Michigan and upstate New York. External peer review contributes to the development of the students' ability to present their own

positions and hear, understand, and respect other points of view. Hence, Level-5 activities develop appreciation of diversity and present a step toward becoming a "good citizen."

Level-6 Activities: International Peer Review of News Items. Level-6 presents the step from external to international peer review. The courses whose students review each other could be taught in different countries. Border-crossing peer review presents a powerful strategy to stimulate the students' global awareness and provides a mechanism to add a global dimension to news media based authentic learning activities. The international peer review alone will go a long way in developing the students' global awareness. The peer review results enter the grade and the students need to be aware of the international perspective while they work on their projects. The next stage would involve the integration of topics of specific bilateral relevance and the ultimate challenge would be presented by international collaboration in the preparation of the group projects. Level-6 activities thus present an opportunity to help students to become "good global citizen."

Tools and Components of "Chemistry is in the News"

The central component of the "Chemistry is in the News" project is a database of "news items" and various software tools are needed to mine and manipulate this database. The required tools include a "news item creation tool," a "database navigation tool," a "peer review tool," an "internal peer review matching tool" and an "external peer review matching tool". All of these functions can be accomplished using HTML editors and a thorough organizational plan and, in fact, the prototype implementation was accomplished in this fashion. Yet, for the project to be applicable on a large scale and adoptable by others, online tools need to be developed that facilitate these rather time-consuming tasks and these software tools are now under development.

The "news item creation tool" allows for the creation and deposition of a news item (article, keywords describing the societal and chemical issues, editorial comments with embedded links, questions, answers) in the database. News items can be created by students as well as by content experts (advanced graduate students, post-doctoral associates, faculty). As the database of online news items increases quickly (by about 40 - 50 items per large lecture course), a "database

navigation tool" facilitates access to the news items in a variety of ways (by chapter for a variety of popular textbooks, by keywords, by popularity as measured by hits, by peer review score, by ranking in peer review, by connectivity to other news items, …). Level 4 - 6 activities require a "peer review tool" so that each created news items can be evaluated by a specified number of groups, in a specified number of categories and according to specified guidelines using both scores and comments and justifications. The peer evaluations are stored in the database as part of the news item. The "peer review matching tool" randomly assigns a specified number of groups to the review of a given number of specific news items.

We envision that in future more and more authentic teaching materials will become available on the web. The richness of these online teaching materials will eclipse the content of textbooks in both quality and scope. The superiority of the web-based materials will not be a matter of degree but a matter of magnitude. The web offers text, graphics and animation, video and audio and the web intrinsically is a more flexible medium than print. Staying up-to-date will be easier than ever; the web format can be corrected, updated and revised with ease. The content of a book is greatly affected by production costs and price competitiveness. On the other hand, web materials are not constrained and storage is a minor cost factor. Teachers will be able to chose from a greater selection of better teaching materials than ever before. With this shift to the online delivery of teaching materials, textbooks will have to refocus from "coverage of organic chemistry" to the new goal of teaching an *understanding* of key issues of organic chemistry. This paradigm shift is already well under way and the *Organic Chemistry* text by Ege (33) is pioneering in this regard. In the latest edition, Ege decided to *remove* some materials from the book while *adding* technology-enriched materials on the companion web site.

Implementation of Level-2 Activities in Large-Lecture Courses

The Setting at the University of Missouri–Columbia. At MU, the majority of students learn Organic Chemistry by taking the sequence of courses Chemistry 210 (200+ students) and 212 (150+ students). MU also offers the respective honors' courses Chemistry 216 and 217 for

up to 50 students. The Chemistry 210/212 and 216/217 sequences employs the texts by Wade (11) and Bruice (10), respectively. The present author wrote "Chemistry is in the News" items to accompany both sequences of courses. For each chapter, one actual newspaper article was selected with a topic relevant to society and related to the chemistry discussed. Graphical user interfaces were written that provide hot-linked access to the news items together with keywords characterizing the societal issues and the chemical topics that are being addressed (34). The author taught the courses Chemistry 210 and 212 in the winter semesters of 1999 and 2000, respectively, and access to all aspects of the courses, including the "Chemistry is in the News" project, is provided via the course web sites (35). The Chemistry 21X web sites contain various kinds of information and we will focus primarily on "Collaborative Semester Projects" and "Chemistry is in the News." Collaborative student groups are formed early in the semester.

"Chemistry is in the News" Items: Issues, Topics, Transferability and Scope. The headlines of news articles, source and date of publication, societal issue raised, and relevant chemical topic addressed can be viewed on the web (34) for the texts by Bruice (10) and by Wade (11) and this information also is provided in two tables in the supplemental material. Chemistry truly is the Central Science! The topics cover a wide range of issues and this breath truly reflects the pervasiveness of organic chemistry in all aspects of life. While the books by Bruice and Wade differ significantly in organization and emphasis, the key issues occur in both texts and most news items can be employed with minor adaptation for both texts. In fact, news items can be written in a format that make them essentially independent of the specific text used.

The articles vary from 200 to 2500 words and most articles are within a few hundred words of the average of about 900 words (about three double-spaced pages). The lengths of the editorials greatly depend on the complexity of the issues addressed; some editorials are just a few sentences and they can be as long as two double-spaced pages. The editorials may contain links to relevant online resources and these links are selected using quality, credibility and stability criteria. Overall, we aim at limiting editorials to about 300 words (about one double-spaced page). Thus, on average length of an article and the associated editorial is about four double-spaced pages. Brevity is a

virtue and the goal of the "Chemistry is in the News" items is not broad coverage but in-depth analysis and evaluation instead. The analysis is guided by the questions; each item contains 3 – 5 questions that are chosen so as to realize a good representation of as many types of questions (see table in supplemental material for details about categories of questions). Most of the news items contain a question that provokes reasoning about philosophical, societal and political implications to create discussion and debate. We briefly discuss two representative examples of "Chemistry is in the News" items to illustrate a few of the pertinent considerations that went into the selection of the topics and the writing of the items.

Figure 1 about here

Pesticides. Nucleophilic substitution is one of the central topics of organic chemistry instruction. To connect this chapter to a real world issue, we selected the article "Ban Is Sought On 5 Pesticides To Protect Kids". This article was published in *The Arizona Republic* on January 29, 1998 (36,37). The article is about the adverse health effects of organophosphate pesticides and it is reported that "the chemicals environmentalists propose banning are methyl parathion, dimethoate, chlorpyrifos, pirimiphos methyl and azinphos methyl." There are several obstacles to making the connection between this article and the chemical principles and concepts students learn in the course. In the article commercial names are used for the pesticides. To think about the chemistry of the pesticides, the students first need to know the structures of the compounds. A good part of the editorial is dedicated to this issue and *ChemFinder* (38) is employed to finding the structure. With the structure of methyl parathion known (Figure 1), the students are presented with the difficulty of applying nucleophilic substitution chemistry to the pesticide. Many students have great difficulty in applying the mechanism of nucleophilic substitution to a molecule as complex as methyl parathion. It is difficult to recognize the "leaving group" of the substrate when the leaving group comprises most of the molecule. The situation is further complicated by the fact that methyl parathion contains more than one center that can undergo nucleophilic substitution. Still another difficulty concerns the fact that nucleophilic substitution of methyl derivatives usually are taught as "a substitution of the leaving group X by the nucleophile Y" and it is non-trivial for the students to

change perspective and to recognize this process as "a transfer of a methyl group from X to Y" or as "a methylation of Y." The first two questions guide the students to learn about the structures of the pesticides structures and their S_N chemistry. The third question is meant to stipulate discussion of philosophical, ethical and judicial issues concerning the use of pesticides.

This news item is based on an article published in January of 1998 and it was employed as a teaching material within a year of publication. Aside from addressing a *current* issue, such activities also prepare the students to better appreciate any related *future* news. The pesticide news item stresses this potential long-term benefits in an excellent fashion. On August 2, 1999, the Columbia Tribune reported under the headline "EPA to ban fruit pesticide," that the Environmental Protection Agency banned methyl parathion from use on all fruit and many vegetables (39). On June 8, 2000, the EPA banned the use of chlorpyrifos in gardens and homes (40). On December 5, 2000, it was reported that the EPA requires the phasing out of diazinon (41).

Figure 2 about here

Protease Inhibitors and HIV. In 1997, the *Medical Tribune News Service* reported in an article entitled "Future Of Aids Therapy Seen In Combining Protease Inhibitors" (42) that "a combination of two protease inhibitor drugs can suppress levels of the HIV virus to undetectable amounts." This news item illustrates well several of the guiding principles of the news item design. First, the editorial provides clarification of the types of drugs for AIDS treatment and it does so with reference to high-quality, credible and time-stable links. Johns Hopkins University is one of the national centers of Aids/HIV research and the embedded link to the "JOHNS HOPKINS *AIDS Service*" puts up-to-date knowledge at the students' disposal. It is the second major purpose of the editorial to address the mechanism of action of protease inhibitors. Animations are employed for this purpose and the "HIV infection" link in the "Cells Alive!" site provides for excellent explanations of the role of HIV protease in the disease process and of the concept of HIV protease inhibition. The "scissors analogy" leaves a lasting impression in the students' minds. With the concept of HIV protease inhibition clarified, the students are prepared to learn about an actual protease and its inhibition. Question 1 contains a link to the visualization materials of this chapter

that shows the X-ray structure of one HIV-I protease with inhibitor (Figure 2). This structure was reported in 1998 and it was first employed in the author's teaching of Chemistry 21X in early 1999. The connection between research and education is direct and immediate!

Implementation of Level-3 and Level-4 Activities in Large-Lecture Courses

Pilot Studies. The implementation of Level-3 and Level-4 activities seemed like a daunting task and the introductory courses to organic chemistry are far too important to allow for the introduction of novel pedagogical approaches before these approaches have matured sufficiently. Hence, several pilot projects were carried out. In the winter semester of 1997, we employed collaborative group projects and used peer review for their evaluation (23). It was the primary challenge at that time to explore how computer-assisted communication can be employed to facilitate the process (group formation, project creation, posting and review) in a large lecture setting. The process was refined in several small graduate courses and these experiences were important with a view to the selection of the type of projects (43). Collaborative group activities in these graduate courses involved two projects, one project involved the creation of a problem set and the other one was very much oriented toward original research. The idea of students creating problem sets as their project was combined with the ideas of the Level-2 news items and, in the fall semester of 1998, the author conducted a pilot study with a group of Chemistry 210 honors' students to explore whether students can create news items in group projects. The pilot project succeeded and, in fact, the students very much liked this concept.

Creation of News Items by Students. Large-lecture implementations were accomplished in the winter semesters of 1999 and 2000 and all of the pertinent materials can be found in the "Collaborative Semester Projects" sections of the course web sites. Introductions to the collaborative group projects, files describing the assignment, peer review instructions, and the completed projects and their evaluations all can be viewed online (44). Groups were formed by self-selection within the first two weeks of the course. The students needed to briefly notify the instructor about the group formation (name of group, names of participants) and the respective

email messages are linked to the groups' names on the project page. The groups of students then identified topics, located online media, placed the material in context and supplied background information in editorials and created questions. About equal time was allowed for the "reading" and the "writing" components of the assignment. At the end of the article selection process (the "reading" component), the groups were required to submit the headline and reference of the online article along with two sets of keywords describing societal issues raised and chemical topics addressed. The reference line is used as the link to the article and the headline is eventually used as link to the completed project. Group 1, for example, selected the article "President signs tough federal law for date-rape drug" which was published by *The Detroit News* on February 19, 2000. The article selection process requires the students to explore a wealth of news media resources available to them. To make this process more instructive and more exciting, "Top-5 News Media" awards (10 extra points) were given to those five groups that employed a particularly appealing (in the judgement of the instructor) news media resource. The selection process required the students to come up with many possible candidate articles and to decide, as a group, which article should be used for the project. Writing the news item required an in-depth analysis of the article and of the issues raised. Seeing the connection is clearly not enough; the group succeeds only if the group members are able to present the connection to their peers with clarity and in context. Students had the option to write their projects directly in HTML and many groups chose this option. Alternatively, the students could write their project in WORD and the HTML tags were added by the teaching staff. "Top-5 Project Awards" (10 extra points) were awarded by the instructor and these awards serve as a guide future generations of students. Three of the "Top-5 Project Awards" winning projects exemplify item writing in HTML and these projects are "Bottle Fed Babies Ingest Cancer Causing Chemical" created by Group 7, "Bad Cough? Aches? Pains? This Man Recommended Heroin" created by Group 22, and "Nicotine Improves Some Symptons Of Parkinson's Disease" created by Group 33. The other two "Top-5 Project Award" winners were groups 27 and 32 and their contributions "Widespread Genetic Fingerprinting Under Debate" And "Draft Legislation For A Ban On Azo Dyes Published" were submitted as WORD files.

Public and Guided Peer Review of News Items. The created news items were evaluated by a public and guided peer review. Each group was required to review five other group projects and to determine scores for each project, based on rubrics outlined in the course web site. Criteria included content, suitability for web publication, relevance to organic chemistry, and the ability of the report to contribute to the reader's learning. The final score for the project was the average of the peer review scores of the five teams. The peer review scores and the evaluative comments were published on the project page in the link "Peer Review Evaluation" in the last line of every group's block of entries. The review was public in that the reviews were *not* anonymous and because the comments were displayed in public. We feel that this public review increases the quality and fairness of the peer review. Peer review only succeeds *when the peers are qualified to judge* and the level of qualification can present a serious limitation to peer review in lower level undergraduate courses. Therefore, there is a special significance associated with the quality and the effectiveness of the guidance of the peer review in undergraduate settings. We believe that this concern is addressed in a very satisfactory manner in the "Chemistry is in the News" project. By the time the students engage in peer review, they have already studied close to ten instructor-created news items and they have already gone through the process of creating their own news items. Since the same categories apply to all news items, the students are well acquainted with these categories and the format requirements. Since the peer review was public, it was entirely possible to appeal a score. Such appeals, however, were the exception and all appeals were resolved in a friendly manner and without direct involvement by the instructor.

One score was assigned to each created news item, the average of the five peer review scores for this news item. The peer review activities were not scored at this time. Moreover, the relative contributions to the project by the various members of a given group did not enter the scores. Both of these issues are difficult issues but they need to be addressed in future.

The quality of the student-created news items was high and in many cases truly impressive. With minor changes, many of these news items can be employed as Level-2 news items for the

study by all students in future classes. Hence, the Level-3 and Level-4 "Chemistry is in the News" activities provide a mechanism to update and expand the database of news items.

Performance Assessment of Level-2 - Level-4 Activities

To be effective, the change in the learning activities must be accompanied by changes in the way learning is assessed. The benefits of collaboration quickly dissipate in overall competitive environments (23) and it is thus imperative that the grading is based on an absolute scale rather than a competitive "curve" (45). Second, the "Chemistry is in the News" activities are only effective if the content of the news items is being tested. Hence, we have based about one third of the questions of all tests on the subjects of the news items (46). Moreover, these systemic changes also have led to differences in the way we assess the students' knowledge and their comprehension of other materials. Rather than asking the students to reproduce simple disjointed facts, many of the test questions are more complex and they require the students to be able to make connections and to place the various pieces in context. Third, the peer review scores for the collaborative group projects directly affected the students' grades in a substantial fashion. The students' overall performance was assessed on the basis of three one-hour tests (100 points each), the collaborative group project (100 points) and the comprehensive final (200 points).

Conclusion

Educators, researchers and administrators agree about the value of students' drawing connections between chemistry and the real world. Drawing these connections serves both as an end of chemical education and as a means to facilitate learning. We reviewed various approaches that have been used to accomplish this goal. More recently, such approaches rely more and more on online media and we proposed a taxonomy of "news media based authentic learning activities" to provide a conceptual framework for their description. Ideally, one wants to engage the students in a full range of cognitive skills and the various levels of the "Chemistry is in the News" project can meet this challenge.

The implemention and integration of Level 1 – 4 "Chemistry is in the News" activities in two large lecture courses on Organic Chemistry has been described. Students working in small groups studied, created and judged news items that consisted of an actual and recent newspaper article, editorial comment and questions. The students studied ten to twelve instructor-reated news items, they created one news item, and they reviewed five more student-created news items. These "Chemistry is in the News" activities served several purposes. First, the activities made connections between organic chemistry and societal issues and problems explicit and they required students to think critically about these connections. This provided an authentic learning task in which students were actively engaged with the course content. Second, the activities increased communication and interaction among students and between students and the instructor, making a large lecture course seem less impersonal. Third, the activities provided an opportunity for development of skills central to scientific inquiry and valuable for students' educational and career goals (e.g. collaboration, communication, research skills). Overall, the "Chemistry is in the News" activities create a more effective learning environment within a large lecture course and in doing so they promote students' learning of organic chemistry.

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WSupplemental Material

Tables that list news article information, issues addressed, related chemistry topics and chapter theme for each chapter for the texts by Bruice (SM1) and by Wade (SM2), a table with statistical data about the news items (SM3), and a table that lists categories of the questions (SM4).

Literature Cited

1. Glaser, R. E.; Hume, D. L. *J. Chem. Educ.*, following article.
2. *NSF 96-139 -- SHAPING THE FUTURE: New Expectations for Undergraduate Education in Science, Mathematics, Engineering, and Technology*. A Report on its Review of Undergraduate Education by the Advisory Committee to the National Science Foundation Directorate for Education and Human Resources.
3. *National Science Education Standards*, National Academy Press: Washington, D. C., **1995**.
4. *Science for All Americans*, Project 2061 of the American Association for the Advancement of Science. Oxford University Press: New York, NY, **1990**.
5. Zoller, U; Fastow, M.; Lubezky, A; Tsaparlis, G. *J. Chem. Educ.* **1999**, *73*, 112-113.
6. Singh, B. R. *J. Chem. Educ.* **1995**, *72*, 432-434.
7. (a) Stanitski, C. L.; Eubanks, L. P.; Middlecamp, C. H.; Stratton, W. J. *Chemistry in Context - Applying Chemistry to Society*, 3rd ed.; McGraw-Hill: Boston, MA, 2000. (b) Stratton, W. J.; Silberman, R. G.; Stanitski, C. L.; Schwartz, A. T. *Laboratory Manual, Chemistry in Context - Applying Chemistry to Society*, 3rd ed.; McGraw-Hill: Boston, MA, 2000.
8. Sherman, A.; Sherman, S. J. *Chemistry and our Changing World*, 3rd ed.; Prentice Hall: Upper Saddle River, NJ, 1992.
9. Hill, J. W.; Kolb, D. K. *Chemistry for Changing Times*, 9th ed.; Prentice Hall: Upper Saddle River, NJ, 2001.
10. Bruice, P. Y. *Organic Chemistry*, 2nd ed.; Prentice Hall: Upper Saddle River, NJ, 1998.
11. Wade, L. G. *Organic Chemistry*, 4th ed.; Prentice Hall: Upper Saddle River, NJ, 1999.
12. Vollhard, K. P. C.; Schore, N E. *Organic Chemistry - Structure and Function*, 3rd ed.; W. H. Freeman and Company: New York, NY, 1999.
13. Carey, F. A. *Organic Chemistry*, 4th ed.; McGraw-Hill: Boston, MA, 2000.
14. McMurry, J. *Organic Chemistry*, 4th ed.; Brooks/Cole Publishing Company: Pacific Grove, CA, 1996.

15. Solomon, G.; Fryhle, C. *Organic Chemistry*, 7th ed.; John Wiley & Sons: New York, NY, 2000.
16. Brown, W. H.; Foote, C. S. *Organic Chemistry*, 2nd ed.; Saunders College Publishing: Fort Worth, TX, 1998.
17. Hornback, J. M. *Organic Chemistry*, 1st ed.; Brooks/Cole Publishing Company: Pacific Grove, CA, 1998.
18. See URL http://www.newslink.csupomona.edu/college/index.html.
19. (a) The home pages of *Sigma Xi*: http://www.sigmaxi.org. (b) The Media Resources Service: http://www.mediaresource.org/news.htm.
20. The INFOTRAC home pages of Wadsworth and Broosk/Cole can be found at the URLs http://www.infotrac-college.com/wadsworth and http://www.infotrac-college.com/brookscole.
21. Fessenden, R. J.; Fessenden, J. S. *Organic Chemistry*, 6th ed.; Brooks/Cole Publishing Company: Pacific Grove, California, 1998.
22. (a) Bloom, B. S., Engelhart, M. D., Frost, E. J., Hill, W. H., & Krathwohl, D. R. *Taxonomy of Educational Objectives. Handbook I: Cognitive Domain.* David McKay: New York, NY, **1956**. (b) Biehler, R. F.; Snowman, J. *Psychology Applied to Teaching* 5th ed.; Houghton Mifflin Company: Boston, MA, 1986.
23. Glaser, R. E.; Poole M. L. *J. Chem. Educ.* **1999**, *76*, 699-703.
24. Bonwell, C.C.; Eison, J. A. *Active learning: Creating excitement in the classroom*. ASHE-ERIC Higher Education Report No. 1. Washington, DC: Association for the Study of Higher Education, 1991.
25. Freeman, M. *Assessment and Evaluation in Higher Education* **1995**, *20*, 289-300.
26. Rafiq, Y.; Fullerton, H. *Assessment and Evaluation in Higher Education* **1996**, *21*, 69-81.
27. Russell, A. A.; Chapman, O. L.; Wegner, P. A. *J. Chem. Educ.* **1998**, *75*, 578.
28. Kelter, P. B.; Jacobitz, K.; Kean, E.; Hoesing, A. *J. Chem. Educ.* **1996**, *73*, 933-937.
29. Barka, K. M.; Barka, L. H. *J. Chem. Educ.* **1996**, *73*, 931-933.

30. Henderleiter, J.; Pringle, D. L. *J. Chem. Educ.* **1999**, *76*, 100-106.

31. For information about the Precautionary Principle, see for example: (a) http://www.ec.gc.ca/cepa/ip18/e18_01.html and (b) http://www.biotech-info.net/precautionary.html

32. Towns, M. H.; Kreke, K.; Sauder, D.; Stout, R.; Long, G.; Zielinki, T. J. *J. Chem. Educ.* **1998**, *75*, 1653-1657.

33. S. Ege *Organic Chemistry - Structure and Reactivity*, 4th ed.; Houghton Miflin Company: Boston, MA, 1999.

34. Chemistry 210/212: http://web.missouri.edu/~chemrg/wade/21x_news_items_w4.html and Chemistry 216/217: http://web.missouri.edu/~chemrg/bruice/21x_news_items_b2.html.

35. Chem 210, WS99: http://web.missouri.edu/~chemrg/RG_T_WS99.html.
Chem 212, WS00: http://web.missouri.edu/~chemrg/RG_T_WS00.html.

36. To accompany Chapter 6 of Wade: http://web.missouri.edu/~chemrg/wade/chapter6/wnews_6n.html. To accompany Chapter 9 of Bruice: http://web.missouri.edu/~chemrg/bruice/chapter9/news_9n.html.

37. The original article can be viewed in *The Arizona Republic Archives* which can be accessed online at URL http://www.azcentral.com/archive/.

38. Chemfinder is an online service of Cambridge Soft at URL http://chemfinder.camsoft.com/.

39. See URL http://archive.showmenews.com/archive/1999/aug/19990802news10.htm.

40. See URL http://www.arizonarepublic.com/news/articles/0608PESTICIDEBAN.html.

41. See URL http://www.discoveryhealth.com/DH/ihtIH/WSDSC000/333/341/305096.html

42. To accompany Chapter 24 of Wade: http://web.missouri.edu/~chemrg/wade/chapter24/wnews_24n.html. To accompany chapter 21 of Bruice: http://web.missouri.edu/~chemrg/bruice/chapter21/news_21n.html.

43. (a) Spectroscopy, Chemistry 416, FS97, http://web.missouri.edu/~chemrg/RG_T_FS97.html.
(b) Computational Chemistry, Chemistry 433, WS98,

http://web.missouri.edu/~chemrg/RG_T_WS98.html. (c) Computational Organic Chemistry, Chemistry 412, FS99, http://web.missouri.edu/~chemrg/RG_T_FS99.html.

44. Chem 210, WS99: http://web.missouri.edu/~chemrg/210w99/210_group_projects.html. Chem 212, WS00: http://web.missouri.edu/~chemrg/212w00/212_group_projects.html.

45. Kovac, J. *J. Chem. Educ.* **1999**, *76*, 120-124.

46. "Tests & Outcomes" of Chemistry 210, WS99: http://web.missouri.edu/~chemrg/210w99/210_tests.html. "Tests & Outcomes" of Chemistry 212, WS00: http://web.missouri.edu/~chemrg/212w00/212_tests.html.

47. Home Page of the Central Midwest Region Chemical Education Advisory Committee, http://www.missouri.edu/~ceac

Table 1. Taxonomy of "News Media Based Authentic Learning Activities".

Level	Activity	Quality Review	Resource	Outcome
1	Read News Article	none	online news media	Knowledge Comprehension Application Analysis Synthesis Evaluation
2	Read News Items editoral & questions	Instructor Review	Online Database & Software Tools	
3	Read & Create News Items	Instructor Review		
4	Read & Create & Judge News Items	Internal Peer Review		
5	Read & Create & Judge News Items	External Peer Review		
6	Read & Create & Judge News Items	International Peer Review		

Figure Legends

Figure 1. Lewis structure of the pesticide Methyl Parathion.

Figure 2. Structure of an HIV protease with bound inhibitor.