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The Roundtable of Scientific Communication: From Classroom to Course Creation, Back to Classroom and Beyond

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The Round Table of Scientific Communication: From Classroom to Course Creation, Back to the Classroom and Beyond

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Table of Contents

List of Figures

List of Tables

Abstract

This research encompasses many aspects of chemical education research including curriculum and pedagogical changes to the freshman and sophomore courses. Curriculum changes included the addition of recitations to the general chemistry and organic chemistry lectures and the creation of four new classes, CHEM 1001, 1002, 3091, and 3092. The addition of recitations was not limited to but was focused on improving DFW rates for these courses.

CHEM 3091 and 3092 are chemistry internship and undergraduate teaching assistant classes. These courses were necessary to offer outside internship opportunities and training for undergraduate teaching assistants, respectively. CHEM 1001 and 1002 are chemistry classes for nonscience majors. These courses were created to attempt to increase the number of nonscience major students choosing chemistry to complete their science requirement. CHEM 1001 and 1002 were courses not offered at any other university and required that the course materials and textbooks for these classes to be created from scratch without any foundation from other courses. An unforeseen consequence of the creation of these courses was the need to improve scientific communication between scientists and non-scientists and even scientist and scientist.

Pedagogical work included a video intensive lecture style (VILS) for disseminating the material in the newly created CHEM 1001 and 1002 courses. For general chemistry and organic chemistry lecture, the major change was the addition of required recitation sessions for these courses. Further pedagogical changes to the organic lecture included introduction of video lectures, implementation of active learning in the lecture and graded, online homework.

Keywords: chemical education; chemistry; pedagogy; curriculum; video; active learning

Introduction

Pedagogical research into chemical education is over 100 years old. The earliest mention of teaching (or pedagogical) methodology in the American Chemical Society journal database is an article in the *Journal of Physical Chemistry* from 1899 on reaction velocity and equilibrium.[1] In subsequent years, there were a number of articles including book reviews and pedagogical approaches to teaching both lecture[2,3] and lab.[4-6] On a cursory glance at the literature, most of the articles focused on reviews of new textbooks or lab experimentation, especially for general chemistry and analytical chemistry. A seismic change in chemical education research occurred in 1924 with the publication of the first issue of the *Journal of Chemical Education.*[7] American chemist Neil E. Gordon (1886-1949)[8] founded the journal in 1924. Gordon founded the Gordon Conferences in 1931 while at Johns Hopkins. He called the conferences the Gibson Island Conferences, but they were subsequently renamed the Gordon Conferences in 1948.

In 1924, the Division of Chemical Education (DIVCHED) was founded[9] with the purposes to "bring about closer cooperation between high schools, colleges and industries and thereby unify the efforts of all those interested in chemical education."[10] There are a number of articles[11-13] that describe the early work of the *Journal of Chemical Education* including an article by Neil Gordon. In 1998, on the 75th anniversary of the *Journal of Chemical Education* an article[14] was published about the first 75 years of the journal. Articles were also published on the 50th anniversary[15] and the 25th anniversary.

During the eight-year tenure of Neil Gordon as editor, there were a number of articles on how to teach freshman chemistry, how does research affect teaching, how to visualize chemical reactions, how to use motion pictures to aid in teaching chemistry. Many of those questions are questions still being addressed by chemical education researchers in 2019. Gordon's tenure as editor focused on both secondary education (grades 9-12) and educational research as well as techniques aimed at post-secondary (college) education.[16] Gordon and the Journal were almost 100% financially supported (outside of ad revenue) by the Chemical Foundation (not to be confused with the Chemical Heritage Foundation), a nonprofit created by Francis Garvan that was promoting the chemical industry of the United States in their quest for independence from the German pharmaceutical and chemical industry.

In 1932, following the stock market crash in 1929 and the expiration of the Chemical Foundation's patents (also in 1929), Gordon was asked to continue as editor but also to assume all financial responsibility for the journal.[17] Gordon could not accept that responsibility, so he declined. Otto Reinmuth agreed to take over the journal and served as editor from 1933-1940. To keep the journal fiscally stabile, Otto drastically reduced the secondary and post-secondary educational research and instead focused on current chemical research. The journal was unofficially branded a 'Living Textbook of Chemistry'.[18] Reinmuth guided the journal through these tumultuous times and instituted the page size and changing cover graphics/images that are still used today.

Norris Rakestraw served as editor from 1940-1955. Rakestraw's contribution included bringing financial stability to the journal by doubling the circulation, paying off all debts and building a surplus for the journal. Rakestraw also instituted the continuing features, Out of the Editor's Basket in 1940 and Tested Demonstrations in 1955. The journal returned to a focus on chemical education research in the post-secondary classroom, however the amount of secondary education coverage continued to drop from a high of 14% during Gordon's tenure to

6% in 1933 (Reinmuth) and maintained at 6% in 1948 during Rakestraw's tenure. The percentage of high school chemistry coverage continued to dwindle past Rakestraw's tenure, bottoming out at around 1% in 1973. By 1997, the amount of high school chemistry coverage had risen back to 3%.[19]

In 1955, William Kieffer took over the editorship of the journal and continued as editor till 1967. Kieffer categorized his time as one of great change. "Chemistry in the college and university classroom changed dramatically during this time. The old struggle between theoretical and descriptive influences on the content of the first course almost disappeared in favor of the theoretical."[20] Kieffer also led the journal during the advent of television, a proliferation of textbooks and reference guides, and the first uses of programmed instruction via filmstrips and super 8 movies. Additionally, computer use for problem solving and simulation became a teaching aid during his tenure. These changes led Kieffer to state "When we reflect on all the influences, both on what we were teaching and on how we were teaching it, those years 1955-1968 appear indeed to have been a watershed period for chemical education."[21] Kieffer further commented he thought the biggest contribution to and for the journal was in selecting his successor, Tom Lippincott.

William T. Lippincott served as editor of the journal from 1967-1979. Lippincott's tenure was known for his introduction of columns in the journal that represented all of the journal's diverse contributors and readers. Lippincott was also a practitioner of modern pedagogical approaches to teaching chemistry such as using computers, films, and projecting information on large screens during lectures. Lippincott was also a co-author on a general chemistry textbook and the principal investigator for the NSF project that created the ACS textbook

ChemCom: Chemistry in the Community.[22] "Perhaps it is not too trite to suggest that all of the exciting new knowledge, all the important new research, all the great new ideas developed by our generation and those that preceded us have neither lasting meaning nor real significance unless the young people of today and tomorrow can appreciate them enough to use them in discovery and building the better world for which they search."[23]

J. J. Lagowski served as editor of the journal from 1979-1996. Lagowski was a professor of chemistry and education at the University of Texas at Austin and served as the director of the Institute for Science and Mathematics Education since 1993. The very end of Lagowski's tenure was marked by the introduction of two powerful active learning techniques, Peer Led Team Learning[24] and POGIL.[25] Also, during this time, Peer Instruction[26] was introduced in physics and active learning became one of the main topics of chemical education research. In an editorial published late in 1995,[27] Lagowski suggested that higher education was in need of a triage to combat a series of unprecedented challenges he predicted will be facing higher education. Those challenges included economic trends (lowering of federal and state spending on education), demographic trends (changing face of the students entering higher education), accountability for affordable and accessible education and heightened scrutiny of the effectiveness of higher education. Lagowski[27] asserted that educators cannot afford to make cosmetic changes but needs to make fundamental changes that included:

- Establish and prioritize the institution's educational goals.
- Establish value and reward systems for students and faculty that are consistent with the priority goals.
- Develop leverage and constrain mechanisms to effect change and improve student orientation to the new priorities
- Establish a relationship between the price and cost of education and access to it, perhaps incorporating some sort of internal subsidy system.

- Develop a relationship between the demonstration of public accountability through the reallocation of resources and the measurement of tangible outcomes that justified enhanced public and private investment.
- Devise a use of technology that improves productivity, which in turn requires the definition of productivity in an academic setting.

In an editorial in 1981, Lagowski also championed the education of non-scientist is as important as the education of science students. “For the educated layman who cannot understand science, the alternative to a priestly elite in a democracy is to vote science out…A democratic elimination of science would make us slaves of a different sort.”[28]

John W. Moore took over as editor of the journal in 1996 and served as editor until 2009. As with all editors since Lippincott, Moore specialized in chemical education research during his academic career. Moore’s tenure saw a proliferation of active learning techniques that started at the end of Lagowski’s tenure (PLTL, POGIL, Peer instruction) and blossomed during Moore’s tenure. The rise of clickers and other lecture tools was one big advancement of chemical education during Moore’s tenure. Moore’s initiatives included incorporating computers into chemical education. He wanted this to not only be for the computer experts but also for computer novices. Moore was co-editor of the Computer Series that first appeared in 1979. He also founded the *Journal of Chemical education: Software* in 1988, which was created to give authors of software credit for their work. Moore’s philosophy can be seen in his editorial as editor. “Applying to the problem of improving undergraduate education the same kind of thought and creativity that go into research projects is something we all should do more often.”[29] “The students…are crying out for teachers who respect them enough to ask for their very best performance."[30] "In a world in which change is the norm, only an educated student has been properly equipped to prosper."[31]

Norbert Pienta is the current editor of the journal and began his tenure in 2009. His 10 years tenure as editor started with being a member of the task force that forged the co-publication agreement between the journal and the Publication Division of the ACS. Pienta also is highly involved in chemical education research and focuses on web-based tools, electronic data collection for the lab, and K-12 education. Pienta's tenure at the journal included the dramatic rise of online homework and online textbooks and the research associated with online material. Also, during Pienta's tenure, research on active learning and clickers continued to be a driving force in chemical education research. Some of the more recent developments in chemical education research included atoms first approach to general chemistry lecture, mechanistic approach to organic chemistry lecture and the introduction of eye tracking hardware as a research tool.

Studying the history of the *Journal of Chemical Education* can provide a guide for the future of chemical education research. The research discussed in this dissertation focuses on many topics that have been talked about for the close to 100-year history of the journal. Specifically, this dissertation will focus on curriculum development, pedagogical advances in the classroom, and improving scientific communication. Curriculum development includes the addition of recitations to the general chemistry and organic chemistry lectures and the creation of two nonscience major chemistry classes (CHEM 1001, The Chemistry of Movies and TV and CHEM 1001, Chemistry of Our Daily Lives) and two internship classes (CHEM 3091, Chemistry Internship and CHEM 3092. Undergraduate Teaching Apprenticeship).

Pedagogical advances in the classroom includes the approaches used in the general chemistry and organic chemistry recitations, organic chemistry lecture and nonscience major chemistry classes. For recitations, the main approach was to use problem-based learning, specifically Peer-Led Team Learning (PLTL). For the lecture, a combination of active learning,[32] Just-In-Time Teaching (JITT)[33] and Problem-Based Learning (PBL)[34] were incorporated into the lecture. For the nonscience major courses, a new lecture style was developed called Video-Intensive Lecture Style (VILS).[35,36]

The use of pre-recorded videos is standard in flipped classrooms or JITT. These videos are used as a means of introducing and teaching topics to students prior to them coming to the lecture. The lecture is then used for problem solving and higher-level discussion. Thus, the traditional mode of teaching, lecturing by the professor during the class and problem-solving by students on their own, has been flipped. Flipped[37] classrooms have become fairly mainstream in the science and the research on these is well established. The occasional use of videos in the classroom lecture has been reported as has the use of YouTube videos[38] by ACS[39] and other organizations for scientific communication. However, an intensive use of videos as the main lecture methodology has not yet been presented in literature and the success of this methodology in the nonscience major courses created at the University of New Orleans (UNO) was instrumental in the communication of science to nonscience majors. Since this style of lecture had not been previously reported, the acronym VILS (Video-Intensive Lecture Style)[40] was created by the author of this dissertation. VILS was determined to be a highly effective teaching style for communicating scientific concepts to a nonscience major.

Chapter 1 Curriculum Changes for Recitations and Internships

1.1 Implementation of Recitations and Undergraduate Teaching Assistantship (CHEM 3092)

Sometime in 2003, it was suggested that recitations could be used to help improve performance in general chemistry and organic chemistry lectures. Recitations are one-hour problem solving sessions that are usually worth zero credit hours. Recitations were not used in any courses at the UNO in 2003. Recitations are fairly ubiquitous in the Midwest and Northeastern United States and have been used in college chemistry courses for almost a century.[41] In New Orleans, Xavier University of Louisiana has been using drills (their term for recitations) since the early 80s under the leadership of Professors Carmichael and Sevenair[42] of the Chemistry Department at Xavier. After a small debate within the faculty, it was agreed to incorporate recitations on a voluntary basis for organic chemistry to see if they were beneficial to students. Voluntary organic recitations were started in 2004. The students who participated gave favorable reviews to the recitation sessions. However, the students participating were also overwhelmingly high performing students who would have received an A grade, even without the recitations.

The department agreed that the best way to make the recitations most beneficial to all students was to make the recitations mandatory. There was some debate amongst the faculty about making a mandatory recitation for all students and if it was mandatory should the students get credit for the course, i.e., should organic lecture become a 4-credit course with 3 credits for lecture and 1 credit for recitation. The department decided to pursue a zero-credit recitation that was mandatory for general chemistry and organic chemistry. The changes to these courses were presented to the college and university courses and curriculum committees and approved in 2005. The courses with mandatory recitations were offered for the first time in fall 2005 and have remained as a permanent fixture in the department till present day. [43]

Recitations in the chemistry department followed a similar pedagogy to the PLTL methodology and were loosely based on a model used at the University of Texas-El Paso.[44,45] Recitations were tied to a specific lecture and capped at 20 students. For example, CHEM 1017 with an enrollment cap of 120 students would be divided into 6 sections, CHEM 1017-001-006. All 120 students would attend the same 150 minutes of lecture each week but each section of 20 students would have a separate 50-minute weekly recitation section led by a graduate student. Initially, each lecture faculty was allowed to design the content and the methodology used in each section and there was no restriction on how to use that 50 minutes of recitations.

However, most every faculty started preparing a worksheet each week that would be provided to the students for them to work on during the recitation session. Students could work alone or in groups on this worksheet. The graduate teaching assistant (GTA), acting as a peer mentor, would float around the room offering help as needed. The GTA were told not to lecture for more than 5 minutes at the beginning of the recitations. They just needed to introduce the topic and explain very basically what should be done. But it was discovered that some GTA were lecturing for 15 minutes or more and treating the recitation like a lecture. The situation was addressed and the recitations were refocused on problem solving only, not lecturing.

Students never received answers to the recitation worksheets but instead were encouraged to work on them in the recitations session and confirm their answers from the GTA.

Often the GTA were not given solutions either but encouraged to work the problems themselves and then ask the faculty member before recitation if they had any questions.

GTA would lead five or six recitations sessions per week for their teaching assignment for a semester. The workload was equivalent to the workload of a laboratory teaching assistant who taught two three-hour labs per week for their teaching assignment for a semester. There was not a lot of oversight initially on these recitations and some faculty turned over most of the work to the GTA. The program continued on more or less in this fashion for the next 6 years. During the 2012 SERMACS regional meeting (where multiple faculty were discussing the using UTA in both recitations and in lab), Professor Morton Hoffman of Boston University was presenting on the use of UTA at Boston. After the talk, he provided details on how students were hired, trained, utilized and paid in this program. The concepts that Professor Hoffman had talked about were discussed by the department of chemistry and it was decided to investigate implementing UTA at UNO.

A select group of undergraduate students were invited to run some recitation sections in organic chemistry on a trial run. The UTA performed excellently in their role. The students in the class thought the UTA were fantastic and they expressed that they were more likely to feel comfortable asking the UTA questions than the GTA. Because of the positive reviews from the students and the faculty observing the UTA performance, the department decided to proceed with the plan to use UTA in general chemistry and organic chemistry recitations and labs. After deliberations, the department decided to create an undergraduate teaching intern class (CHEM 3092) that students would take their first semester as apprentice UTA. CHEM 3092 was proposed and approved (Appendix 1.1). Students were required to sign a syllabus/contract (Appendix 1.2) for their teaching internship.

Apprentice UTA were evaluated throughout their internship semester and at the end of the semester, the instructor in charge of the UTA course (using student feedback and training UTA feedback) decided if the UTA were ready to graduate from their apprenticeship to leading a recitation on their own. If they were deemed prepared, the next semester those students would become full UTA and lead recitations on their own that semester. Following that first semester, the student could opt to take the internship class up to two more times for a total of six credit hours. The new undergraduate teaching internship, CHEM 3092, was approved in 2012 and over a two-semester period GTA were phased out of use in recitations as a cohort of UTA were trained and prepared for use in recitation. By 2013, all general chemistry and organic chemistry recitations were led by UTA.

The UTA program was so successful in the recitations that a proposal to implement UTA in the teaching labs was approved. UTA usage in teaching labs was not quite as successful. Many UTA were not as confident about being used in the teaching labs and some faculty were hesitant about using UTA in the lab as lead TA under the supervision of a GTA. A handful of UTA went through the lab training program. While some of the UTA decided not to continue in the program, a number of highly successful UTA completed the program and served as UTA for multiple semesters. Many of these students went on to successful graduate student careers and based on their feedback they were much better prepared to be a GTA because of this program.

1.2 Analysis-Recitations and Undergraduate Teaching Assistantship

Based on initial improvement in DFW rates and student feedback, the recitation program was judged to be highly successful. After 7 years, the recitations had become stagnant with GTA running the recitations more than faculty. Faculty had grown a little lax and GTA were experiencing some frustration with their roles in these recitations. Some of the frustration was from the work and some was from the responsibility of the recitation program falling more on their shoulders. The solution to this problem was the replacement of GTA with UTA.

The replacement was beneficial for all parties involved. GTA were now responsible for just lab classes and the strain of stretching too few GTA over too many courses was alleviated. UTA were excited to be an active part of the education process. UTA were also able to gain many important soft skills (such as time management, person responsibility and better communication skills) along with a deeper understanding of the courses they taught. The students in the class received excellent peer mentoring and instruction from a true peer who they were more comfortable interacting with than with a GTA or professor.

The department was able to shift valuable GTA resources to lab work and research where they were most needed. Additionally, retention of majors was increased with the advent of the UTA program. An increase in the number of chemistry majors was noted during this time even though the overall enrollment in the university was declining. The increase was due not only to how students in freshman and sophomore level chemistry courses felt that they were valued and being given the best education possible but also because of the opportunities the department offered such as the UTA program.

The UTA program was a major undertaking. Scheduling classrooms for 30-40 one-hour recitations each week was difficult enough but finding UTA to cover all of the available times was even tougher. Through trial and error, the program blossomed, and the scheduling became easier as a more or less permanent timing for recitations was settled on based on student and UTA feedback. CHEM 3092 also matured during this process. Initially, weekly UTA meetings covered trouble shooting from previous week recitations and review of the upcoming week's material. After a year or two, there was a steady state of experience UTA and new UTA. The weekly UTA meeting started to incorporate role-playing to anticipate scenarios that might arise in recitation. Review of literature articles that focused on PLTL, peer mentoring and instruction was incorporated and UTA were expected to read and write a summary of those articles.

Overall, the UTA program (along with recitations) was a resounding success in the department. Recitations (and UTA) helped improve DFW rates, increase recruitment and retention of majors and provided for improved soft and academic skills for the UTA.

1.3 Future Work-Recitations and Undergraduate Teaching Assistantship (CHEM 3092)

Recitations have already undergone one major change when the responsibility for recitations was shifted from GTA to UTA. This change occurred almost 7 years after recitations were first introduced. The switch from GTA to UTA occurred 7 years ago and recitations have potentially stagnated again. Potential future improvements to recitations could include an overhaul from a guided tutoring session to a more structured POGIL or PLTL model. There are a number of games that have been developed to teach nomenclature, bonding and other topics in general chemistry that could be incorporated into the general chemistry recitation. Organic chemistry has seen the development of apps for mechanisms, reactions, chair structures and other topics that could be incorporated into the organic recitation.

Originally, the recitation was a mandatory 10% of students grades but did not include formal grading of quizzes or work but was graded on attendance and participation only. The 10% now is a minimum but could also include active learning in the classroom and online homework. Because of this, the recitation may have become marginalized. Many students refuse to come and are willing to sacrifice these points in favor of studying on their own or using the time for other pursuits. Some faculty allow for “forgiveness” of the missing points if all other grades meet the minimum for an A. The recitations have become a little scattered and non-cohesive.

An overall head to toe analysis of the recitations should be conducted. While many universities conduct recitations similar to UNO (the rules of the recitations are dictated by the faculty teaching the courses), the schools (such as UTEP and Xavier) that have shown continued excellence in recitations have a very well-defined and rigid structure. It might be wise to have the undergraduate coordinator conduct a review and implement a framework of support for the recitations. A simple fix would be to create a workbook of problems that the students could purchase (or download from the department website). The workbook could contain Learning Objectives (LO) for each week of recitations, along with a set of worked problems and a couple of sets of unworked problems for each week of class.

The workbook could be developed with the faculty of the course and could serve not only for recitations but for students coming to the Chemistry Learning Center (CLC), where UTA have office hours. A potential reworking of the recitation would have this workbook serve as the main tool that students would use to practice problems for lecture and during the week could come to the CLC for help. During the recitation the students could get more help on the week's LO and try some more problems. At the end of recitation, there could be a weekly quiz on that week's LO. This would create an actual grade for the recitation that was not subjective on attendance and participation but on graded material. Potentially, each recitation might be worth 20 points, 5 of which came from participation and attendance and 15 from the quiz (or some similar rubric).

The benefits to this methodology would be twofold. For the faculty and the UTA this would provide a definable and concrete way to assign grades from the recitation that would not rely on a subjective grading scale and give rise to student complaints at the end of the semester. Secondly, this should help the students by encouraging them to keep up with the material. Each week they would be required to master that week's LO, which they would be tested on at the end of recitation. It is anticipated that students would require less "cramming" of material right before the test and would perform better overall in the class. The changes suggested could be tested for efficacy by one or more of the following:

- comparison of DFW rates from previous years to current year cohort
- comparison of performance of tests grades from previous years to current year cohort
- survey of UTA and faculty on general impressions of student preparedness
- survey of students on how prepared they felt for tests using this methodology.

The recitations were designed initially to do what is described above but by making them more based on attendance and participation instead of actual outcomes and by not have a formal structure, there has been some back-sliding which is shown by raising DFW rates in these service courses, especially general chemistry.

While some faculty might suggest that students should be doing this on their own, there is no doubt that students (especially freshman and sophomore) need this “hand-holding”. Xavier University of Louisiana use an even stricter version of this methodology. Student in general chemistry and organic chemistry have a 2-hour recitation or drill each week. In general chemistry, the drill consists of graded worksheets and quizzes. In organic drill, students discuss problems and ask question for an hour and then have a 1-hour test each week. These drill tests are worth 500 points out of the 1000 points available for the class, while the two midterm lecture tests are worth only 200 points. Discussions with current Xavier faculty and students have made clear how important the drills are for the success of the students. The biggest complaint about biochemistry (junior year course for many premed students) at Xavier is that there are no drills or workbooks for this course. However, many of the students have started an impromptu weekly review session on their own and have implemented a pattern of studying a set of LO each week like they did for organic as a tool to help them succeed in their biochemistry lecture.

Implementation of these changes should result in decreases in DFW rates, increases in student retention of material, and better test performance. The implementation of weekly quizzes should also show students that the best way to prepare for science classes is to study continuously throughout the term instead of waiting to the test to cram in the material. It is hypothesized that this will help students build better study skills that will help them in their upper division classes and beyond.

Regardless of what is eventually decided, a thorough analysis of the recitation program needs to be undertaken with the goal of improving on what is working and fixing what is not working. The analysis needs to take input from faculty, UTA and students (current and former) in the freshman and sophomore level chemistry classes.

The undergraduate teaching assistantship class, CHEM 3092, has not been revamped in the 7 years since its inception. In spring 2017, small changes were added to the CHEM 3092 curriculum. On two occasions during the semester, UTA were asked to analyze relevant chemical education research articles and were also asked to develop their own lessons for the recitation (Appendices 1.3 and 1.4). The plan was to continue and expand this in future semesters. However, due to circumstances, this was never implemented.

It is suggested that going forward, the weekly CHEM 3092 meeting of UTA include review of research articles and UTA creation of lesson plans. At least two times per semester, UTA should be given a research article and be asked to write a summary of the article and how it could be implemented at UNO. At least once per semester, UTA should be asked to search the current literatures (past 12-24 months) and find an appropriate article to share with their fellow UTA, including a written summary of the article. Finally, at least once or twice per semester, UTA should be asked to create a lesson for an upcoming week of recitation. The lesson can be a simple one-page summary of the topic (including worked examples) and a set of practice problems. The UTA should share this with the other UTA who will suggest improvements to the lesson. If deemed appropriate, the lesson then should be implemented during the appropriate week of recitation. These lessons can also become part of future updates to workbook and/or weekly quizzes. If included in the workbook, the students can gain a credit within the updated workbook.

The suggested changes will give a real depth to CHEM 3092 that has been missing. The changes should improve the research literacy of the UTA (something all undergraduate need), give UTA exposure to lesson planning, which will be highly beneficial for UTA going to graduate school and help them to feel like a true part of the UTA program. The UTA should feel that they are partners with the faculty in the recitation and this will help them feel that way. Anecdotal evidence from past interactions with UTA do not suggest they feel that partnership.

In addition to changes to the CHEM 3092 course, a full study of the impact of the program on the UTA should be undertaken. This has been proposed in the past but has not occurred due to time constraints and other issues. One metric for measuring impact of the program on the UTA can be easily assayed by giving a pre-test to all UTA coming into the program for the first time. The pre-test should be either the final exam for CHEM 1018 or ACS General Chemistry Exam (for general chemistry UTA) or should be either the final exam for CHEM 3218 or ACS Organic Chemistry Exam (for organic chemistry UTA). At the end of the first semester of CHEM 3092, an equivalent post-test exam should be given to the UTA. They should be asked to NOT study for either exam so that a base level of their understanding of the material can be analyzed. It is expected that there should be an increase in the performance from the pre-test to post-test. After their first full semester as UTA (after completing their internship semester), the post-test should be administered again, and the performance should be compared. If the program is achieving the expected results, a significant increase should be seen from the original pre-test to this post-internship test.

Research should also be conducted on performance of the UTA cohort versus non-UTA cohort in upper level chemistry classes, such as CHEM 3411, Descriptive Inorganic Chemistry and CHEM 4210, Intermediate Organic Chemistry. Although final overall performance in the class may not see a drastic difference in performance from these two cohorts, the faculty in those courses should see an improvement in the baseline retention of core material that students should know coming into those courses (general chemistry for CHEM 3411 and organic chemistry for CHEM 4210).

Another potential research study could follow these students through professional or graduate school and compare their overall success versus the rest of their class who were not UTA. This may not be as useful as the overachieving student will tend to be the ones that go through the UTA program. But it would be interesting to see if there is a difference especially amongst students who might not be at the top of the class.

Finally, an analysis of the improvement in student's soft skills could be investigated. There are some studies available on this topic and it might be easy enough to adjust the questionnaires and surveys used in these studies to test the soft skill improvements in our UTA after going through this program.

1.4 Implementation, Analysis and Future Work of Chemistry Internship (CHEM 3091)

A chemistry internship, CHEM 3091, class was approved in 2012 (Appendix 1.5). This class formalized a framework for students who performed internships outside of the university. Prior to this student internships were arranged almost exclusively by the students and had no formal affiliation with the university. The creation of this course provided students both the opportunity to earn credit for their internships and also provided protection for them since they were now under the umbrella of the university while performing their internship at an offsite location. For the companies, the internship provided a formalized process for employing university students as interns along with strengthening ties to the university.

Internships were established with USDA, Eurofins, Thionville Labs, New Orleans and St Tammany Parish Crime labs. A number of students have gone on to earn fulltime employment at these companies. In 2015, Eurofins established a partnership with the UNO that included both internships, scholarships and an endowed professorship starting in 2016.

Students are required to sign a syllabus/contract (Appendix 1.6) for their internship with the department and the company. The company outlined the requirements that students need to fulfill to complete their internship. The instructor of record for the class coordinated with the contact person at the internship at least twice per semester to make sure the student was meeting their obligation and received a final written report from the company for the successful completion of the internship (Appendix 1.7).

The course has a variable credit load and may be taken multiple times for up to nine credit hours maximum. Each credit hour requires three contact hours at the internship. With approval from the department, four credit hours of credit may be substituted for the required four credit hours of research that all chemistry majors must complete for their degree requirements.

The implementation of the chemistry internship course has proven to be a great success. The chemistry internship course is at least partially responsible for the partnership between UNO and Eurofins. A number of students who graduated from the chemistry department at UNO with a BS have been employed full-time at Eurofins, Thionville and USDA. Additionally, these companies have also employed MS and PhD graduates from the department. Students who used CHEM 3091 to replace the required CHEM 3094 (undergraduate research) helped alleviate a potential problem for the department when there was not enough space in faculty research labs for all the undergraduate students who needed to complete their undergraduate research.

Overall, there is very little that needs to be changed or updated for the future of this course. The department need to continue to nurture the relationship with Eurofins and USDA that has been created in part through this internship class. The department should identify other companies where UNO students may intern and work with those companies to create a mutually beneficial partnership like UNO has with Eurofins.

Chapter 2 Creation of Nonscience Major Chemistry Courses

2.1 Lights, Camera, ACTION: The Chemistry of Movies and TV (CHEM 1001)

In 2013, proposals (Appendices 1.8 and 1.9) were submitted to create two new chemistry courses at the University of New Orleans. The first proposal was submitted for *CHEM 1001: Lights, Camera, Action: Chemistry of Movies and TV*. The second proposal was submitted for *CHEM 1002: Life, the Universe and Everything: Chemistry of Our Daily Lives*. These new nonscience major courses would be incredibly fun and popular while at the same time increasing the overall student credit hours for the Department of Chemistry. However, the mail goal of these courses was to simply provide a fun and innovative way to communicate science to a nonscience major and to show those students how to think scientifically, think critically and be skeptical.

At UNO, all nonscience majors are required to take nine credit hours of science courses.[46] All students must take three credit hours of biology and six more credit hours of science, but six of the nine must be a two-semester sequence of courses, such as General Chemistry 1 and General Chemistry 2. In 2012, the vast majority of students opted to take BIOS 1053: Human Biology for Nonscience Majors and BIOS 1063: Biodiversity for Nonscience Majors[47] as their two-semester sequence. The last three credit hours could then be taken from any course offered in the Biology, Chemistry, Earth and Environmental Sciences (EES) or Physics Department.[48]

Biology had a stranglehold on these nonscience majors since they were required to take one biology. Having taken one biology already, many of them opted to do their two-semester sequence or their entire nine credit hours in biology. Earth and Environmental Sciences (EES) gained a good share of students by offering courses in Dynamic Earth, Environmental Science and Dinosaurs. Physics offered Astronomy 1 and 2, which were very popular. Chemistry offered General Chemistry 1 and 2, which were some of the least popular science courses amongst science majors and these courses were even less popular amongst nonscience majors.

Therefore, the goal was to create a two-semester sequence to compete with the popular offerings from the other science departments. Initially, a Chemistry of Breaking Bad was proposed for one of the classes in the sequence. However, this idea quickly morphed into CHEM 1001, Chemistry of TV and Movies to avoid using only one show that may fall out of popularity fairly quickly and may not provide an entire semester of material. For the second course, a course was needed that would still be fun and exciting, but also something more practical and real for the students. This led to the proposed course, CHEM 1002, Chemistry of Our Daily Lives. CHEM 1001 was envisioned to have a video-intensive (or video-enhanced) style of teaching, while CHEM 1002, would have a more traditional lecture-style pedagogy.

The first course in this two-semester sequence, the Chemistry of Movies and TV (CHEM 1001), was much easier to develop than Chemistry of Our Daily Lives (CHEM 1002). Much of CHEM 1001 had been outlined prior to submitting the course for approval. *Breaking Bad*,[49] *Game of Thrones*,[50] *Star Trek*[51] and *Doctor Who*[52] would form the backbone of the syllabus for CHEM 1001. CHEM 1001 was approved and was offered for the first time in the spring 2014 semester. During the summer and fall semester of 2013, the rest of the course syllabus for this new course was developed.

Initially it was proposed that the chemistry of *Game of Thrones* would be the first unit of the course and *Breaking Bad* would be the last unit of the course. During the development of rest of the course content, it was decided that instead of starting with *Game of Thrones* the course would instead start with a review of some basic chemistry content. The chemistry (science) of *Game of Thrones* would follow the introduction of chemistry concepts.

Following the unit on *Game of Thrones*, would be a unit on the chemistry (science) of *Star Trek* and *Doctor Who*. The next unit would be a unit on the chemistry of other science-fiction and fantasy works including some history of early science fiction writers. The next unit would be on classic movies/books that have a strong tie to chemistry. Specifically, the chemistry of *The Invisible Man*,[53] *The Strange Case of Dr. Jekyll and Mr. Hyde*[54] and *Frankenstein; or, The Modern Prometheus*.[55] After an investigation of the chemistry in these classic literature titles would be a unit on superhero chemistry based mostly on movies in the DC and Marvel universe. The chemistry of the *Jurassic Park*[56] and *Jurassic World*[57] franchise would follow superhero chemistry. The course would conclude with the longest and most in-depth unit, the chemistry of *Breaking Bad*.

CHEM 1001 would be different pedagogically from any other course offered in the department if not all of the courses offered at UNO. The lessons for the course would involve playing a video clip from a movie or TV show followed by a discussion of the chemistry shown in that clip. Therefore, the main task in creating the lesson plans for this course (after deciding on the larger topics for the units) was determining which clips from each of the media would be used in the lecture. The most common and easiest way to come up with lesson plans for a new course was to search the literature and current textbooks in similar courses to come up with potential lesson plans. Unfortunately, since this course was unique and there was not much in either the literature or in published textbooks to help create lesson plans for this course, this was not a viable option.

Since there was no other course like this, there were no available textbooks. There were a few mainstream books that were published on the subject. The best three found were *ReAction! Chemistry in the Movies*[58] by Mark Griep and Marjorie Mikasen, *Hollywood Chemistry When Science Met Entertainment*[59] by the ACS Symposium Series, and *Chemistry and Science Fiction*[60] by Jack Stocker.

Mark Griep's book provided much of the foundation for the lesson plans for *The Invisible Man, The Strange Case of Dr. Jekyll and Mr. Hyde* and *Frankenstein; or, The Modern Prometheus*. Jack Stocker's book provided the foundation for much of the lesson plans for *Star Trek* and *Doctor Who*. The ACS Symposium Series book did not provide individual lesson plans but gave good suggestions on topics to be used in the course. However, the vast majority of the lesson plans would need to be developed using some other methodology.

Literature search did not provide much support either. There were some articles by Mark Griep,[61,62] however, many of these were already discussed in Griep's book. Other literature articles[63-67] provided a framework on how to build lesson plans but did not provide the lesson plans directly. At this point it was determined that internet searches and cobbling together clips along with developing almost all the lesson plans from scratch would be the best and only way to create this course.

To make sure of the success of this class, careful preparation went into designing the course. The design of all the lesson plans took over 9 months and was constantly updated over the first four years the course was offered to reach the final course as comprised today. The first lesson created was for the opening day lecture (described in section 2.2). The lecture was based on giving students a broad picture of what scientists do and how scientists think. The lecture also focused on showing the students how they could also (and should also) think like a scientist. They should be skeptical of everything they saw and heard and should think critically about what they see and analyze it for voracity. The method for disseminating the lesson has changed over the five times the course was taught but the basic learning objectives for the first lecture has not changed.

For every lecture, students are provided a series of student lecture notes and given access to all videos shown in the lecture. Initially student feedback and active learning was done via paper quizzes and/or surveys. Clickers were implemented in the second iteration of the course (although paper quizzes were still utilized for some questions). In the third iteration of the course, an online textbook written by the creator of the course and utilizing the Top Hat platform[68] was added to the course. Concurrent with the implementation of the Top Hat textbook was the introduction of an online cohort of students that included an online section for any student from UNO who wanted to do the course as an internet course and a section for students who were seeking an internet only degree.

In the latest iteration of the course, all student notes, instructor notes, access to videos, clicker quizzes, online homework and interactive textbook were available in TopHat.[69] Student notes consisted of an outline for each unit's lesson plans. Instructor notes included detailed notes on how to incorporate videos into the lesson and what to discuss in each lesson. Daily quizzes, called problems of the day (POD), were also placed in the instructor portion of TopHat. POD could be administered either during lecture or online. While some POD were more traditional questions the students would answer, other POD included having the students watch a video and then answer questions about the video. These POD were developed to increase the student's critical thinking skills.

This work was not accomplished in a simple, linear pattern as described here. The work for creating the course would bounce back and forth from picking topics for a unit to developing a lesson plan to finding videos to creating student notes. Additionally, the fine tuning of the course was only possible after presenting the lecture to students and finding what worked and what did not work. More than once a lesson plan had to be scrapped for future iterations of the course because it was not successful (or for some other reason) and more than once a new lesson plan was created because of a discussion in the lecture where students suggested potential topics to discuss or a new topic sprang organically from class discussions.

2.2 Development and Evolution of Lesson Plans for CHEM 1001

After an introduction of the syllabus, course requirements and other basic information, the first lecture of the course proceeds with a series of internet memes[70] that were used to explain thinking critically and being skeptical. Data (and personal observations) have shown that Generation Z[71,72] is a digitally native group of students who look for videos and internet sources as their first choice for knowledge and help with classes. The use of memes or infographics, such as in figure 1, 2 and 3, were a much faster and efficient way of disseminating information to students. The first infographic explains the scientific method in an alternate way so that students can understand it visually.

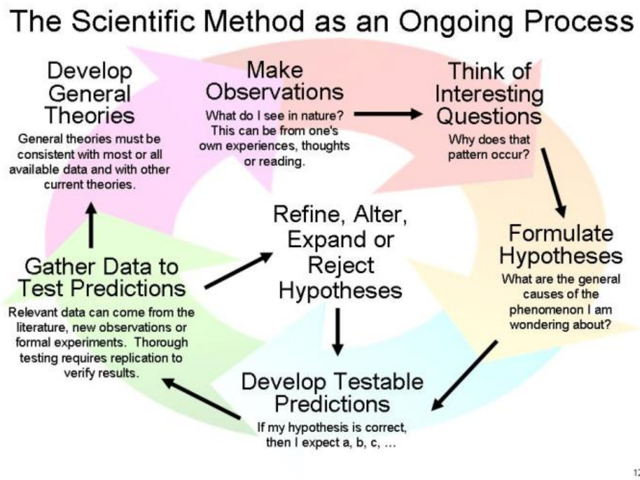


Figure 1: Scientific method. Courtesy of https://commons.wikimedia.org/wiki/File:Scientific_Method_3.jpg; Attributed to Whatiguana [CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0)]

The other memes help the students realize they must be skeptical even on the most innocent and truthful seeming information from the internet. Figure 2 seems innocuous and is trying to show that the current pope has been a friend of scientists and is himself a scientist. However, Pope Francis actually has the equivalent of an associate degree (from a community college) in chemistry not a master's degree. While not egregious, this is still factually wrong and shows that you need to be skeptical about everything you find on the internet.

Figure 2: Meme from internet showing innocuous inaccuracy. No verifiable original source or copyright for this image.

Figure 3 shows another seemingly innocuous error. In the meme from Figure 3, a supposed quote is shown from the Dali Lama about his teachings on science and Buddhism. Although the meme in figure 3 paraphrased the actual quote, the meme put the paraphrase in quotations to indicate that this was a direct actual quotation, which is wrong. The actual quotation from the Dali Lama is “If scientific analysis were conclusively to demonstrate certain claims in Buddhism to be false, then we must accept the findings of sicence and abandon those claims” (Dalai Lama XIV, *The Universe in a Single Atom. The Convergence of Science and Spirituality*).

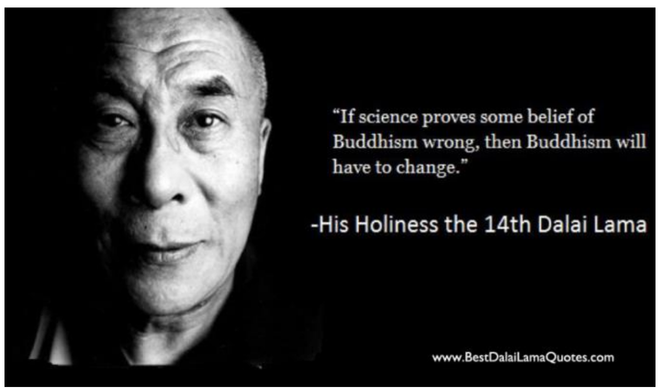


Figure 3: Meme from internet showing misquote of the Dalai Lama. Images courtesy of https://www.bestdalailamaquotes.com and Google Books. Image has no copyright and is freely shareable (www.bestdalailamaquotes.com/about-us/)

It was decided that there needed to be a big splash to end the first lecture to hook the students into the class and demonstrate the type of material and POD that the students would see through the courses. The clip chosen to end the first lecture was from *The Hobbit: The Desolation of Smaug.*[73] In the clip, the dragon Smaug is chatting with the hobbit thief, Bilbo Baggins. At the end of the clip, Smaug attempts to kill Bilbo with his fire. After watching the clip, the students would be given the following POD.

After watching the video clip from the Hobbit showing Smaug breathing fire, answer the following:

a. Even though fire-breathing dragons do not exist, how could a creature breathe fire…what would it need to create the fire?

b. What would the dragon need to protect the dragon from the flame coming out of its mouth?

At the beginning of the second lecture, a discussion about dragon fire was held. Students were introduced to hypergolic liquids via a video from Periodic Videos YouTube channel,[74] and videos on the bombardier beetle and how they generate hypergolic liquids to attack and kill their predators and prey. This then led to the introduction of a clip from the movie *Starship Trooper*,[75] which had a giant-sized bombardier beetle that shot fire from its antennae. This is a typical lesson plan for this course. It is also typical of how one idea for a lecture (dragon fire) can serendipitously lead to another media example (*Starship Troopers*).

The second lecture not only expanded on critical thinking and being skeptical but also introduced and explained the scientific method. Students were explained how to evaluate of facts and information for voracity. The concepts of pseudoscience, correlation vs causation, "the dose makes the poison" and the Dunning-Kruger effect were introduced to the students.[76] The memes and internet figures that were used in this lecture were supplemented by various videos that helped explain the material. The introduction of "dose makes the poison" led into a discussion of poisons used in various media including the TV shows like *Law and Order*,[77] *Person of Interest*[78] and *House*[79] and the movie *Spectre.*[80] Chapters 1 and 2 of the text book covered the material in these lectures.

The next unit was on basic chemistry concepts such as atomic structure, chemistry definitions, states of matter, gas laws, electromagnetic spectrum and some basics of biochemistry. A video from *WKRP in Cinncinati*[81] was used to explain subatomic particles. For states of matter, videos on how lightsabers are contained plasma and how the liquid terminator from *Terminator 2: Judgement Day*[82] works were used. A clip from a rat breathing a fluorocarbon liquid mixture from the *Abyss*[83] was used to explain the bends. A video from *Deep Impact*[84] was used to explain both the electromagnetic spectrum and a different view of states of matter.

An overview of biochemistry included discussions about neurotransmitters and diseases associated with those including Parkinson's diseases. To explain further about Parkinson's, videos of the effects of Parkinson's with Muhammad Ali and Michael J. Fox were shown and then video clips from the movie *Awakenings*[85,90] were used to explain the disease and how L-Dopa was used to temporarily "cure" Parkinson's. Chapter 3 of the textbook covered these basic, chemistry concepts. The topic of biochemistry also gave a good segue to the chemistry of *Game of Thrones*, which was the next unit in the course.

Topics covered in the *Game of Thrones* unit included the impossible science of the "Wall", the science of seasons and climate, the chemistry of Valyrian steel, the chemistry of Wildfire (similar to Greek Fire), the science of incest and genetics, the chemistry of poisons and drugs and the psychological and medical conditions of characters. The *Game of Thrones* unit took multiple weeks to cover during the semester. In addition to clips from the TV show, the discussion brought in other media including *Harry Potter and the Chamber of Secrets*[86], *Avatar*[87], *The Rock*[88] and *Pulp Fiction*.[89] Additionally, to help explain the science of *Game of*

Thrones, many videos from YouTube channels such as *Periodic Videos*, *ACS Reactions*, and more were used in this unit.

The next topic was the chemistry (and science) of science fiction and fantasy. Topics covered included an introduction to science fiction writers with chemistry and other science backgrounds, such as Michael Crichton, Isaac Asimov, Arthur C. Clarke and many others. The various inventions that were inspired by science fiction was another topic covered in this unit. There were three episodes discussed from *Star Trek: The Original Series* that covered chemistry of aging, spy communication and viral infections. These same topics were covered in *Star Trek: The Next Generation*.[91] The lesson for these episodes not only covered explanations of the chemistry involved in the episode, but also how the presentation of the material changed based on both the scientific knowledge and political climate when the episodes were aired (1960s vs 1980s-1990s)

Doctor Who was covered next in the course. Although multiple episodes of *Doctor Who* were covered in passing, the chemistry and ethics of genocide in *Genesis of the Daleks* and the chemistry of regeneration were discussed in more in-depth. *Star Wars* was the next show covered. Multiple small topics were covered including lightsabers, the death star, blasters and so on. However, much of the science of Star Wars is more related to physics and engineering so was not covered in this course.

The next topics covered were the chemistry of *Frankenstein*, *Jekyll and Hyde* and *The Invisible Man*. Each of these literary works (and their corresponding movies) contained a good bit of chemistry. *Frankenstein* had multiple references to chemistry including the chemistry of reanimation. *Jekyll and Hyde* had inspired multiple chemists to do a forensic analysis of the

Hyde formula to decipher what chemicals are involved in that formula. Between hints in the literature and Robert Louis Stevenson's real-life illness and the medicine he took for his illness, a very good estimate of the contents of the Hyde formula has been developed.

In *The Invisible Man*, the chemical that causes invisibility is monocaine. Through subsequent reimagining of the story in different movies, the composition of the invisibility chemical (always a -caine, such as monocaine, duocaine…) and its pharmacology changed quite a bit. These changes and other topics were covered in this lesson. The discussion of *The Invisible Man* led into a discussion of invisibility cloaks, along with a comparison of the ways that an invisibility cloak could work (and is being researched). Additionally, the discussion of monocaine, led to a discussion of the Novocaine and other anesthetics, which led to a discussion of cocaine. The history of cocaine as an early anesthetic and readily available stimulant was discussed along with its current status as a class

The final lesson of science fiction was the chemistry (and science) of the cartoons *Futurama*[92] and *Rick and Morty*.[93] Although multiple topics could be covered in *Futurama*, the main topic covered from this is an episode about climate change. In *Rick and Morty*, most of the science is physics and engineering. There are some chemistry topics discussed, including an interesting bit about using titanium nitrate and chlorified tartrate to make ovenless brownies.

The next unit was on the chemistry of superheroes. Topics included how Captain America, The Hulk and The Fantastic Four got their powers. Also, the physical consequences of Quicksilver running past you or being punched by Superman or shrinking like Antman are discussed. The horrible inaccuracies of Fraulein Doctor's chemistry manipulations of mustard gas in *Wonder Woman*,[94] the chemistry of *Batman* and the carbon footprint of superheroes are also part of this unit.

The second to last unit of the course covered the chemistry (science) of *Jurassic Park* and *Jurassic World*. The first big topics from this unit is the chemistry of PCR and the process of cloning animals and the degradation of DNA, which is one of the reasons cloning dinosaurs is impossible. This leads to a discussion of real-like cloning (such as what is done at Audubon Center for Research on Endangered Species) and the de-extinction of certain extinct animals such as the wooly mammoth.

The last unit was *Breaking Bad*. There was more chemistry in this show than in any other show covered in this class (or maybe any show ever). The chemistry discussed in this unit included the completely inaccurate use of HF to dissolve bodies and the very real dangers of HF. Also, discussed were the use of phosphine as a poison and the real-world dangers of phosphine. In the show, Walter White taught chemistry in high school and a couple of his lectures were also discussed in the class. In one lecture, Walter talked about how transition metal solutions sprayed into a flame changes the color of the flame. In another lecture, Walter talks about the two enantiomers of Thalidomide and how one of the enantiomer is an *antiemetic*, while the other is a *teratogen*.

Fulminated mercury, ricin, thermite and ammonium nitrate bombs were also lessons in this unit. Another huge part of this unit was the history and chemistry of methamphetamines. The different ways to illegally cook methamphetamines by non-chemists were discussed in this unit. Also discussed were the ways that a chemist would synthesize methamphetamines, including stereoselective synthesis of methamphetamines. In discussing these methods, all the dangers associated with the chemicals involved in the synthesis and the process itself were discussed.

2.3 Life, the Universe and Everything: Chemistry of Our Daily Lives (CHEM 1002)

Compared to CHEM 1001, CHEM 1002 only had a generalize concept, which was the chemistry of our daily lives, and a bare bones syllabus at the time of its approval. Therefore, there was a lot of heavy lifting to get this course ready for its first semester. Even choosing the title for CHEM 1002 was much tougher than CHEM 1001. One of the faculty in the department had suggested adding "Lights, Camera, Action" to the title for CHEM 1001 to give it more student appeal, especially to film majors. But for CHEM 1002, there was a tougher time getting an appealing hook to attract students. Additionally, the organization for the second course was an even harder nut to crack. The course was going to deal with how chemistry affected our daily lives, but there was not a clear idea on how to organize the course. Finally, the Chemistry of Our Daily Lives course seemed like it was also going to be tougher to populate with students as opposed to the Chemistry of Movies and TV course, which would be easier to promote with students because of the inclusion of shows like *Breaking Bad* and *Game of Thrones*.

When facing a monumental task of creating a new course, the typical process was to cheat and see what else was available already in the marketplace. A selection of the nonscience major chemistry textbooks[95-98] was obtained from various publishers and the chapter organization of each course was analyzed. The idea was to get a consensus course structure from these textbooks and build a course based on their work. Unfortunately, that did not work out. The textbook organizations were eerily similar for most of the standard textbooks (Tables 1 and 2) and just looked like a watered-down general chemistry course outline. The ACS textbook had a fairly unique structure but was not quite what was wanted for this course. At this point, there was still just a shell of a course without even a proper title.

Table 1: Textbook Structure for Four Different Publisher Textbooks

Overview for Four Different Publisher Textbooks			
Title	Author	Publisher	Unique Features
Chemistry for Changing Times	Hill and McCreary	Pearson	Fitness, Health, Farming
21st Century Chemistry	Waldron	Macmillan	N/A
Visualizing Everyday Chemistry	Heller and Snyder	Wiley	Green Chemistry, Food Safety and Genetics
Chemistry in Context	ACS	McGraw Hill	Portable Electronics, Brewing, Nutrition, Forensics, Genes

Table 2: Topic Distribution for Four Different Publisher Textbooks

Typical General Chemistry Chapters Found in Four Different Publisher Textbooks				
Topics	Chemistry for Changing Times	21st Century Chemistry	Visualizing Everyday Chemistry	ACS
Intro to Chemistry	X	X	X	X
Atomic Structure	X	X	X	
Bonds	X	X	X	
Stoichiometry	X	X	X	
Intermolecular Forces	X	X	X	X
Acids and Bases	X	X	X	
Oxidation and Reduction	X		X	
Nuclear	X	X	X	X
Air	X	X	X	X
Water	X	X	X	X
Energy	X	X	X	X

Since the organization of content was not going well, the focus went back to the title of the course. There was a need for a similar title hook like found in CHEM 1001 (Lights, Camera, Action: The Chemistry of Movies and TV). Instead of simply CHEM 1002: the Chemistry of Our Daily Lives, a catchy title with a hook was needed. A few titles were suggested and rejected but finally the title of the course was settled. The course would be CHEM 1002, Life, the Universe and Everything: Chemistry of Our Daily Lives.

With the problem of the course title settled, the content of the course still had to be built. The issue was how to organize the course so that it is fun for the students, but still has some sort of logical approach and teaches the chemistry that needs to be taught in a nonscience majors course. When all else fails, always go with the simplest solution. The title of the course would be the organizational structure for the course. There would be three units. Unit one would be "Life" and would explore biochemistry, medicinal chemistry and food chemistry. Unit two would be "the Universe" and would cover the electromagnetic spectrum, the sun as the source of our life, all facets of energy, climate change/global warming and ozone layer depletion. Unit three would be "Everything (else)" and would cover vaccinations, GMO, tattoos and nanochemistry.

Chemistry is described as the central science.[99] As a central science, it stands to reason that chemistry will touch all aspects of our life. Not only our life, but all of the universe around us is dependent on chemistry. In reality, everything is dependent on chemistry.[100] Thus, *Life, the Universe and* Everything,[101] which is also the title of the Douglas Adams' third book in the

Hitchhiker's Guide to the Galaxy series[102] would not only be the title of the course but also provide the framework for organization of the course.

2.4 Development and Evolution of Lesson Plans for CHEM 1002

It was determined that the CHEM 1001 course would be offered every fall and CHEM 1002 would be offered every spring. But the first time either course was offered was spring 2014. Therefore, CHEM 1001 would be offered in spring 2014 and fall 2014 before CHEM 1002 was offered for the first time in spring 2015. This little quirk of scheduling turned out to be a great boon for the creation and eventual success of the CHEM 1002 course.

Although CHEM 1001 was supposed to be a video-intensive course, the combination of running out of time to develop all the content and some hesitation about a drastic pedagogical change (tradition lecture to video intensive format) prevented the course from going all out videos in the first semester. There was a large amount of video content, but there was also a fair amount of traditional lecturing. Based on feedback from that first cohort that took the course,[103] course evaluations[104] and faculty reflection, it was decided to retool the course before offering it again in the fall and go full video immersion. Additionally, there was an increase in the amount of content in some areas (popular areas such as *Game of Thrones, Jurassic Park, Breaking Bad*), decrease the content in other areas (unpopular areas such as classic movies) and content was added that was not included initially but students were asking to include (superhero movies). But in every content area of the course that remained or was added, the amount of video content was increased as much as possible.

While CHEM 1001 was always intended as a course to be taught mostly using video content, CHEM 1002 was initially intended to be a more traditional lecture course. However, students were so enthusiastic and excited by the pedagogical approach of CHEM 1001 and the professor was excited by the success in conveying difficult topics using this format, that the initial plans for CHEM 1002 was scrapped before it was taught for the first time.

The pedagogical approach for CHEM 1001 was to show a video clip of a movie or TV show and then discuss the chemistry in that video by asking "Was the chemistry correct or not?", "How can it be related to real world chemistry?" and other similar questions. The traditional pedagogical approach to CHEM 1002 was changed to a video-intensive pedagogy, but it could not and would not be the same as CHEM 1001. With movies and TV, it is easy to show a clip and then ask about the science. With CHEM 1002, a different strategy had to be applied to the video intensive lecture pedagogy.

A general outline of the course was complete. So, the next step was to go through those topics to see which ones could be converted to the new video pedagogy. It was realized that a complete video immersion of many of these topics was not possible. Also, the use of movie and TV clips even when applied to our daily lives was not a desired format for the class. Luckily, the creation of this course coincided with a huge increase in the amount of curated and excellent scientific content on YouTube. Some YouTube science channels had been used as source for material in CHEM 1001. Many of these and other channels such as: SciShow,[105] ACS Reactions, It's Okay to be Smart,[106] Periodic Videos, AsapSCIENCE[107] and even Last Week Tonight with John Oliver[108] were perfect for this course. There was now more video content than was thought possible or could be used. All the content needed to be vetted and for the next couple of months curation of the content was the main focus of the course design of CHEM 1002.

Curating the content focused on finding content that matched the course outline and was entertaining while being scientifically accurate. Not every single topic in the course had a corresponding video lecture, but the vast majority of them did. For the life unit, videos were found to explain the medicinal chemistry process, how cholesterol works, how steroids work, how food digestion works and many, many more topics. But, still there were some topics that did not have appropriate video content. In a great and thankful coincidence, Andy Brunning's great chemistry infographic site, compoundchem.com,[109,110] was being developed and growing in popularity at the same time as the course was being developed. Almost all of the topics that did not have video content had infographics from compoundchem.com or some other website. These infographics were used to build student study notes and used as presentation tools in the lecture, when a video was not available.

The life unit was subdivided into three subunits, biochemistry, food chemistry and medicinal chemistry. Overall, biochemistry took about two weeks of lecture time. The biochemistry lessons in the life unit were further subdivided into carbohydrates, lipids and proteins.

The carbohydrate lesson usually took two lectures. Some of the highlights of this unit include a video from the Periodic Videos YouTube channel on destroying a gummy bear with sulfuric acid, a video on how cows and termites digest cellulose that humans cannot and a video of students running on a liquid corn starch mixture from an UNO science outreach event.

The lipid lesson usually took one and a half lectures. Highlights included an academic video on how "good" and "bad" cholesterol works and much less serious videos on steroids, using old Bud Light commercials with Joe Piscopo and Jim Carey as Vera DeMilo from *In Living Color*.[111]

The final subcategory of biochemistry was proteins. This lesson took one and a half lectures. Highlights included how lactose intolerance works and mummification via a video from ACS Reactions YouTube channel. A summary of these lessons can be found in Table 3.

Table 3: Overview of topics for Biochemistry Lesson for CHEM 1002.

Topics and Media for Biochemistry Lesson in the Life Unit				
Topic	Infographics	Videos	Class Time	Interesting Media
Carbohydrates	12	8	100-150 minutes	Gummy Bear Death; Cow and Termites; Running on Corn Starch
Lipids	9	10	75-100 minutes	How Cholesterol Works; Joe Piscopo; Jim Carey
Proteins	12	10	75-100 minutes	Lactose Intolerance; Mummification

The next subunit taught is food chemistry. Overall, food chemistry took about one and a half weeks of lecture time. The food chemistry lessons in the life unit were further subdivided into basic food chemistry, cooking, drinks and molecular gastronomy. The basic food chemistry lesson usually took one lecture. Some of the highlights of this unit include a video demonstration of Alton Brown making ice cream, and a series of videos from ACS Reactions YouTube channel on why chocolate is bad for dogs, what garlic, onion and hot peppers do to your body.

The chemistry of cooking and chemistry of drinks lesson were usually delivered in the same lecture. Highlights included videos on the Maillard reaction, coffee and the Guinness widget found in cans of Guinness. Molecular gastronomy, science of dieting and lab grown meats were usually delivered in the same lecture. Highlights included a funny "infomercial type" video on dieting from Cracked, a video explaining molecular gastronomy from SciShow and a series of videos on a startup, Memphis Meats,[112] that is heavily invested in producing lab grown meat. A summary of these lessons can be found in Table 4.

Table 4: Overview of topics for Food Chemistry Lesson for CHEM 1002.

Topics and Media for Food Chemistry Lesson in the Life Unit				
Topic	Infographics	Videos	Class Time	Interesting Media
Basic Food Chemistry	52	19	75-100 minutes	Alton Brown Ice Cream; Chocolate and Dogs; Garlic and Onion; Hot Peppers
Chemistry of Cooking	7	7	30-45 minutes	Various Maillard Reaction Videos
Chemistry of Drinks	27	17	30-45 minutes	Coffee; Alcohol; Guinness Widget
Dieting and Molecular Gastronomy	12	11	30-45 minutes	Diet Infomercial; Molecular Gastronomy
Lab Grown Meat	1	4	30-45 minutes	Memphis Meats

The next subunit taught is medicinal chemistry. Overall, medicinal chemistry took about two weeks of lecture. The medicinal chemistry lessons in the life unit were further subdivided into an overview of medicinal chemistry, specific drugs and marijuana. Interestingly, medicinal chemistry had one of the absolute lowest rated (overview of medicinal chemistry) lessons and two of the highest rated (drugs and marijuana). The overview lesson usually took one to one and a half lectures. Some of the highlights of this unit include a video on homeopathy, a video of John Oliver eviscerating Dr. Oz and his pandering to alternative medicine, and an episode from *Seinfeld*[113] about the horrors of going to a holistic healer.

The chemistry of neurotransmitter lesson usually took about one lecture. Highlights included how neurotransmitters work, videos about "Your Brain on MDMA, Fentanyl, Adderall, …." AsapSCIENCE, history of Viagra, sarin gas, toxicity of cone snails and uses of conotoxin. History and uses of marijuana usually took a little less than one lecture (pending student discussion and questions). Highlights included how marijuana works, video of Your Brain on Marijuana from AsapSCIENCE, Doc Vader video on marijuana and an episode of *Seinfeld* about poppy seeds causing a failed drug test. A summary of these lessons can be found in Table 5.

Table 5: Overview of topics for Medicinal Chemistry Lesson for CHEM 1002.

Topics and Media for Medicinal Chemistry Lesson in the Life Unit				
Topic	Infographics	Videos	Class Time	Interesting Media
Overview	17	5	75-100 minutes	Homeopathy; John Oliver and Dr Oz; Seinfeld
Neurotransmitters and Drugs	11	8	125-150 minutes	Neurotransmitters; Your Brain on…; Viagra; Sarin; Cone Snails
Marijuana, CBD	17	12	45-60 minutes	Uses of Marijuana; THC and CBD; Legalization

Similar lessons were created for the universe unit and the everything unit. A more in-depth analysis of specific lesson plans and organization can be found in two chapters written by the author for books in the ACS symposium series.[35,36] Additional, PDFs of both textbooks are available via TopHat or from the author.

Students were asked to assess the videos used in class to make sure that they were appropriate, and students found them entertaining. Videos surveys asked students to categorize the video into four groups.

- The videos were entertaining but did not really help explain the science
- The videos helped explain the science but were not really entertaining
- The videos neither helped explain the science nor were they entertaining
- The videos were both entertaining and helped explain the science

For example, a video on how lactose intolerance works that explained the science of lactose intolerance would be educational. A video that explained lactose intolerance but included funny graphics or humorous situations would be educational and entertaining. A clip from a TV show where a person who was lactose intolerant ate some dairy and then had an embarrassing situation occur would be completely entertaining.

As expected, videos that had both entertainment and educational value were very well-liked by the students. Completely educational videos were also usually enjoyed as long as they were not too long, too boring or presented with a lot of other content that was also tedious and without entertainment value. Completely entertainment videos were thoroughly enjoyed especially if a small lecture after the video explained the relevance of a video. On more than one occasion, videos were presented that were an entertaining clip that related to a topic but were not very relevant; those video usually elicited comments that they were funny but took up class time. An example of the survey is shown in Figure 4.

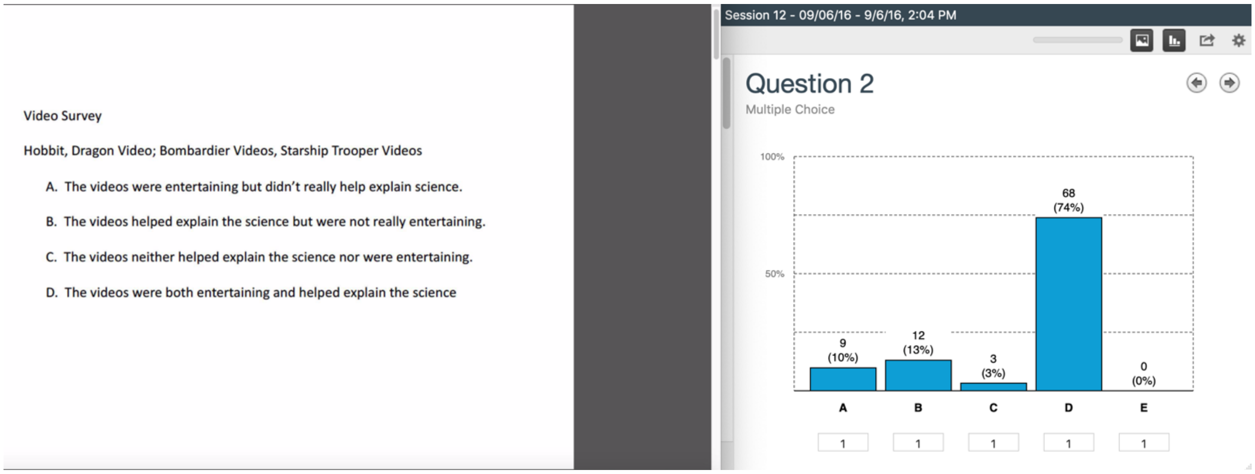


Figure 4: Example of student survey of videos shown in class using iClicker software.

Most of the videos chosen (even the entertainment only videos such as a clip from *Seinfeld*) were rated by at least 70% of the students as both entertaining and educational. Again, the caveat is that entertaining videos had to be followed with a quick explanation of the chemistry involved in the clip. Any video that fell below 50% was revaluated to see if it could be trimmed or combined with another more relevant video or something done to increase its usefulness in class. If not, that video would be eliminated from the video rotation. It might still be available in the textbook or as a suggested video if the content was educational.

Table 6 shows the various YouTube channel sources for the majority of the videos used in the course.

Table 6: List of YouTube Channels used in CHEM 1002.

YouTube Channel	URL
Periodic Videos	https://www.youtube.com/channel/UCtESv1e7ntJaLJYKIO1FoYw
ACS Reactions	https://www.youtube.com/channel/UCdJ9oJ2GUF8Vmb-G63ldGWg
Last Week Tonight with John Oliver	https://www.youtube.com/channel/UC3XTzVzaHQEd30rQbuvCtTQ
It's Okay to be Smart	https://www.youtube.com/channel/UCH4BNI0-FOK2dMXoFtViWHw
SciShow	https://www.youtube.com/channel/UCZYTClx2T1of7BRZ86-8fow
AsapSCIENCE	https://www.youtube.com/channel/UCC552Sd-3nyi_tk2BudLUzA
Kurzgesagt-In a Nutshell	https://www.youtube.com/channel/UCsXVk37bltHxD1rDPwtNM8Q
Because Science with Kyle Hill	https://www.youtube.com/channel/UCvG04Y09q0HExnIjdgaqcDQ
Probably Science	https://www.youtube.com/user/probablyscience
ZDoggMD	https://www.youtube.com/channel/UCFyRz1N_T-rnSkbaAH_TFAw
Minute Earth	https://www.youtube.com/channel/UCeiYXex_fwgYDonaTcSIk6w
VSauce	https://www.youtube.com/channel/UC6nSFpj9HTCZ5t-N3Rm3-HA

Both CHEM 1001 and 1002 have experienced growing pains throughout their evolution. The courses offered today are much more refined and complete than the first iteration of the courses. The amount and the presentation of content was increased, decreased or eliminated based on both student and faculty feedback. In CHEM 1001, content is continually added as new movies and TV shows are developed. Hollywood has partnered with scientific consulting groups[114] to ensure that science is portrayed as accurately as possible in media, which has led to more and more accurate videos for use in CHEM 1001. However, this only works when a movie or TV show hires a scientific consultant. Many shows and movies now routinely hire a scientific consultant, but there are still many that do not (*Wonder Woman*), which has led to another type of video to show in the class.

The initial creation of these two courses was accomplished over an 18 to 24-month period, subsequent revisions and overhaul took another three years to reach the final product that is CHEM 1001 and 1002. The courses have reached a point where there will only need to be minor fine-tuning going forward. The complete course package for each course included an interactive textbook, student notes, lecture notes, instructor notes and full set of POD. These courses can easily be adopted by other schools with little to no effort needed.

2.5 Using YouTube videos

The first semester that videos were used, the faculty would go to YouTube and play the videos directly from YouTube in the class. This had the benefit of being the most legal and ethical way to show the videos. This method relied on internet connectivity (sometimes an issue at colleges), ads to watch (got to pay for the videos) and the chance the video would disappear from YouTube. During that first semester, a film student suggested a browser add on that allowed for downloading the videos. After investigating the safety and legality of the add on, the add on was implemented and all videos were downloaded from YouTube to show in class.

What are the legal ramifications of downloading the videos? The answer is not absolute, and it gets a little murky. Personal use of videos downloaded from YouTube seems somewhat ok. For using in education setting, it seems to be legal. For movies and TV shows, clips were accessed from studio YouTube channels of authorized YouTube sources (such as Movieclips' YouTube[115] channel) as much as possible.

As part of the requirements for the class, students had to create their own YouTube videos about chemistry found in a movie or TV show. These student-created videos were uploaded to the class YouTube channel.[116] Many times there were claims on these videos for using copyrighted materials. Each time an appeal was filed with YouTube and the material was always approved to remain unedited. In the end, the faculty felt there was a legal right to download these for educational purposes based on the fair use and transformative clause of US copyright law[117] and YouTube's fair use policy.[118]

Ethical ramifications of using this copyrighted material was also considered and the faculty determined that it was all ethical. Full credit was given to each channel or studio. Students were encouraged to subscribe to the channels used in the course, if they liked the material. All in all, the channels probably got more ad views from students subscribing than they would from playing the video once per semester with ads. Additionally, the textbook linked out live to the YouTube videos allowing for ad money to go to those channels, many of whom were non-profit and did not use ads to generate money.

2.6 In Conclusion

Organization, time, patience and always looking for potential material are some of the main things needed to create a new course like the ones created at UNO. The foremost thing learned in creating a new set of courses is that it is a very HARD and ARDUOUS task. But once it is done, there was a huge sense of accomplishment that never goes away. Another major lesson was that adaptability is a major requirement for creating new courses. Changes were made to the course that deviated greatly from the original proposed courses. These changes included changing CHEM 1001 from the Chemistry of Breaking Bad to the Chemistry of TV and

Movies and changing CHEM 1002 from a traditional lecture to a video intensive lecture. These changes were made because they were best for the course even if they were not what was wanted initially or expected to happen. One unexpected development that happened during the creative process was the accidental finding of material for the courses in the most unlikely of places. Often a video, topic, lesson or some other item for the course would be discovered serendipitously while doing some mundane task. Answering emails, watching a TV show or movie, reading a news feed or a science blog all provided the spark to create a lesson for the course. There were many Facebook groups and various feeds for newspapers, magazines, science blogs, science aggregation sites that were discovered in the creation process that provided material for this and other classes. Without the creation of these courses, many of these excellent sources would not have been discovered. Often during the creation process (and after), an article, video, news blurb was discovered and put away for future use in this or another class.

One of the biggest keys to the successful creation of this course was the need to be very organized. All videos discovered in the process (whether they were to be used now or later) were stored in a file folder. The folder was subdivided into CHEM 1001 and 1002 and then each of those were further subdivided by topic. When revising lesson plans, this organization was invaluable in finding new assets to use. The notes app from Apple was used to save (and aggregate) interesting articles that were discovered. Periodically, these notes were analyzed to determine their value for the course. If they were deemed valuable, they were sorted into their appropriate folder for the course (i.e., if it is a vaccination article, it goes in the vaccination file) or if deemed to be not of use, they were discarded or saved for later.

In one of the later iterations of the course, it was determined that a chapter on superhero chemistry needed to be added to CHEM 1001. Instead of conducting a long, arduous and time-consuming search for material, all of the material that was previously gathered and curated for future use was searched. In the video folder, was a folder with videos on superhero chemistry. Likewise, the article folders had a folder dedicated to superhero articles. The curation and organization of this potential, future material saved a tremendous amount of time and effort in the creation of this new unit.

When creating a new course, there will always be material that was not used for a variety of reasons. One easy pathway to deal with this excess material was to put this all in one big folder to sort at a later date. An even easier pathway was to delete it all since it was not used. The most complicated and painful pathway was to sort and curate this material fully as the creation process continued. By following the most complicated pathway and by continuing to curate and sort material after the course was created, a huge amount of time was saved later in the revision and updating of content for the course.

In the creation process of these courses, it was expected that knowledge would be gained in many topics of chemistry that are not fully explored in a normal class. But an unexpected and unintended, yet fantastic outcome of the creation of the course was learning about topics where it was not known that there was a deficiency in knowledge, such as GMO foods, or where the deficiency was greater than expected, such as vaccinations or climate change. Even more exciting was learning about topics that were affected by chemistry that the professor was not aware at all of their deficiency, such as tattoo inks.

The goal of these courses was NOT to teach a general chemistry course or a liberal arts chemistry course or to disguise a general chemistry course in window-dressing. The goal was not to recruit new chemistry majors or convert nonscience majors to science majors. The goal was to simply provide a fun and innovative way to communicate with nonscience majors some simple basics of chemistry but more importantly how to think scientifically, think critically and be skeptical.

Another goal was to create a two-semester sequence of chemistry courses that would be very popular with students and increase the student credit hours in chemistry. This goal was not only met but exceeded the expectations of the creation of these courses. The courses are offered once per year; CHEM 1001 in the fall and CHEM 1002 in the spring. The first year, 77 students completed the course. 244 students completed the courses last academic year (Table 7). The courses have surpassed the enrollment of all other non-major science general education courses at UNO except for general biology for nonscience majors, which is required for all nonscience majors.

The enrollment of these courses increased while the enrollment of the university (and especially nonscience majors) has decreased. Additionally, an online section was offered in the third year. There was also a cohort of online degree seeking students who use this course for their science elective. Many of the advisors are pushing students towards chemistry's two-semester sequence of CHEM 1001 and 1002 as the courses of choice for their required two-semester sequence in science.

Table 7: Number of Students Enrolling in CHEM 1001/1002 per Academic Year

Academic Year	CHEM 1001	CHEM 1002	TOTAL
2013-2014	77	0	77
2014-2015	99	90	189
2015-2016	119	114	233
2016-2017	106	97	205
2017-2018	143	101	244

The creation of the courses took about two years of preparation prior to the course being offered for the first time. There were also major revisions and reworking of course material through the first two years the course was formally offered. Little tweaks to course material will continue as the course progresses from year to year. It is logical to assume that the climate change and vaccination section will have changes almost every year, while other sections like tattoos, size and chemistry of universe, basic chemistry concepts will remain fundamentally unaltered from year to year. It is also expected that new topics may be added based on what is exciting and new in chemistry, our daily lives and in new TV and movies. For example, the chemistry of e-cigarettes and vaping was investigated and will most likely be included in the future. There have been some interesting peer reviewed articles on the composition of the vaping liquid and the addiction and toxicity of vaping that make it a compelling topic to add.

The creation of the course was a monumental effort. The writing of the textbooks for the course is still ongoing. The course itself will be constantly updated and will need curation on a year to year basis. But the results have been very encouraging. The course attendance is growing, and students are really excited about the course. The topics are compelling and seem to have created a better understanding and passion for science in nonscience majors. The course has reached a point where it could be expanded and offered at other universities if they were interested in creating a new, nonscience major course but did not want to have to go through the long drawn out process of creating their own course.

There are also a number of exciting lessons within the course that have been highly successful and pushed the pedagogical boundary of teaching chemistry, specifically with the video intensive lecture style. Additionally, the creation and teaching of this course contributed to a realization of the importance of science communication especially to non-scientists. VILS and science communication are discussed in a later chapter of this dissertation.

Chapter 3 Pedagogical Approach for CHEM 1001

3.1 An Example of a Video Intensive Lecture in CHEM 1001

There were a select few books that that were unbelievably helpful[58-60] in the creation of lessons for CHEM 1001. Without these authors, this course would not have been possible. Many of the topics and lessons were "borrowed" quite liberally from their efforts and research, with proper citation of course. However, the lessons and topics that were discovered (or adapted) specifically for this course by the author were some of the most enjoyable to create. The chemistry of neurotransmitters was a lesson created for this course and without much (if any) precedence in literature.

Described below is one lesson plan created completely new for CHEM 1001. This lesson plan is found in the *Game of Thrones* unit but also includes material from other sources such as *The Rock*, *Harry Potter, Pulp Fiction* and various YouTube channels. The lesson plan starts with playing a video from the movie *The Rock*, a synopsis of the clip is listed below.

Dr. Stanly Goodspeed[119] is in an isolation chamber with a suspicious crate, a co-worker and a box of cockroaches. Inside the crate, marked aid to Bosnia, is a doll, dirty magazines and a gas mask. The crate is suspected to have sarin gas inside. While opening the crate, Dr. Goodspeed is testing his co-worker to make sure he knows what and how dangerous sarin is as a toxin. The co-worker picks up the doll and "plays" with it like a child would play with the doll, moving the arms and legs. That movement activates the doll and a stream of gas comes out. The gas is corrosive and threatens the integrity of their isolation suits. There is a C4 bomb in the doll that can blow up the whole room and expose everyone to the toxic gas. The cockroaches start to explode and….

The lesson plan on the poisons used in *Game of Thrones* will start with the video clip from *The* Rock summarized above. At the end of this short three-minute clip, the students will be informed that there is actually a good amount of science in that clip and by the end of class they should be able to understand all of the science in the clip. They will also find out what was correct science and what was incorrect science in the clip.

Starting a lecture with this video clip and getting students invested in the lesson is more likely to keep them focused and attentive for the whole lecture. The first time the course was offered, the lecture started with a dry recitation of facts that went something like this: "Today we are going to talk about the poisons in *Game of Thrones*. *Belladonna* is a real-word poison that comes from a plant found in North Africa. The plant contains chemicals in it that are called alkaloids, which are nitrogen-containing chemicals, such as morphine, quinine, atropine and strychnine, which are derived from plants such. In the show…".[120]

Starting a lecture with a non-active learning pedagogy or even an outline of the day's lesson is expected in many lectures and can be a useful methodology in many science courses and upper level courses. But for a nonscience major's science course with a diverse population of students, this is not a recipe for success. If a film major, English major, business major or some other nonscience major is in their first university science class, would they rather watch the teaser clip or listen to the boring recitations of facts? To most faculty, the answer is obvious. Anecdotally, there was evidence of greater enthusiasm for the video introduction of the lecture, but no actual data was captured on the recitation of facts lecture to draw a comparison between the two methods.

One difference between a nonscience major's science course and a required science course, such as organic chemistry, is the amount of non-traditional material required to be successful. While many faculty have gone to full active-learning lectures[32] or flipped classrooms,[37] a study by Marilyne Stains in Science[121] showed that a significant majority, 55%, of lectures still follow a traditional faculty-centered[122] lecture pedagogy with 27% of lectures mixing a small amount of active learning with traditional lecture. Only 18% emphasized a student-centered pedagogy.[123]

For organic chemistry, a traditional lecture with some active learning[24-26,32-34] was a very good method for communicating with and keeping the attention[124-127] of organic students, who are mostly pre-professional students, chemistry majors or similar. Most STEM majors are expecting a traditional type of communication in organic chemistry and are open and understanding of that method of teaching. However, for nonscience majors, a different type of communication entirely was employed. This methodology is fairly unique to the science lecture and has been called the Video-Intensive lecture style (VILS) and will be discussed in a later chapter.

3.2 The Creation and Evolution of the *Game of Thrones* Lecture on Biochemistry

How did the unique pairing of *Game of Thrones* and chemistry come together? It was part logic, part serendipity, part luck and a bunch of hard work and experiences, both good and bad. When designing the course, having the chemistry and science of *Game of Thrones* as one of the first major units seemed a no-brainer.

Game of Thrones is an extremely popular show with students (and the general public). It would be an exciting way to start the course and get students to buy into the concept of the course. Moreover, there is a surprising amount of chemistry and science in early seasons of *Game of Thrones* including drugs, poisoning, genetics and wildfire. Having decided to incorporate *Game of Thrones* early in the semester, the next task was to determine which science-related parts of the show to include in the lesson plan. Unfortunately, this is not something that can be researched easily. There was not a large number of articles available on using *Game of Thrones* in the classroom. A search of ACS publications using "*Game of Thrones*" returned very little results.[128]

Therefore, lesson plan creation had to rely on pop culture searches,[129] a handful of YouTube videos and knowledge of the material covered in the show. A book on the science of *Game of Thrones*[130] was released in 2016. However, the material that was researched and discussed in the book had already been discovered in researching the individual lessons for CHEM 1001.

When preparing lectures for the chemistry (science) of *Game of Thrones,* there are some obvious candidates from the show that should be considered. Specifically, there was the giant Ice Wall, the erratic weather, all the different poisons and medicines, wildfire and Valyrian Steel. The first iteration of the course centered on these topics. Over the years, topics were added that focused on diseases, such as Greyscale, a taxonomy of animals, beasts and monsters, genetics and even psychological and medical disorders that are found in *Game of Thrones*. Part of this evolution was because more television seasons of *Game of Thrones* were produced with more cool topics and part was just the natural progression of teaching a course a second, third or fourth time.

The lesson presented in this chapter took about three times through the course to develop fully. The very first time this lesson was taught, there was just a PDF study guide and one clip from the show that took maybe ten minutes of class time. By the third time iteration of this lesson, the lesson easily extends to 60 minutes or more to present fully.

In the initial development of this lesson plan, the first step was to get as much information from the show as could be found about the topic. Next, textbooks and articles (if possible) were searched for credible information about this topic. Finally, video clips from the show and other videos to enhance the presentation were found. Now, it would be nice to say this was all happening at the same time in a linear fashion, but it did not happen this way. At various times when teaching or not teaching the course, videos of interest would be found and put away to be used the next time the course was taught. For example, one of the first videos found (and used in the first semester) was from the ACS reactions' YouTube channel. The next video used was a great video from Periodic Videos' YouTube channel, but it was not used till the second time the course was taught. In a later iteration, video clips from *The Rock* to show the use of atropine was discovered and used. SciShow's YouTube channel provided a great video on sarin gas that was used in the third iteration of the course. *Pulp Fiction* provided a good use of the needle in the heart trope[131,132] that was talked about in lecture. Before long there were 13 videos to enhance this lesson.

Below are screen captures from the textbook (Figure 5), class notes (Figure 6) and the instructor guides (Figures 7 and 8) that are used for this lecture. The notes from the textbook are more thorough (as expected) than the lecture notes. The students can access the textbook chapter on *Game of Thrones* anytime to get more information. They can also view clips or link out to other content from the textbook. All the information is cited and only public domain artwork (via Wikimedia commons or similar) and verified YouTube channels are included. The instructor guide notes are a detailed listing of how to present this material and are available for all the lessons that are used in both of these courses.

Real World Application

In our world *Atropa Belladonna* or Belladonna[71] or Deadly Nightshade is a plant found in Europe, North Africa and Asia. The leaves and berries are toxic causing delirium and hallucinations. Belladonna berries are lethal at a dose of 2-5 berries or one leaf. Physiological effects include blurred vision, tachycardia, loss of balance, staggering, headache, dry mouth and throat, slurred speech, hallucination, delirium, convulsions.

Atropine[72] and scopolamine (found in the motion sickness patch) are two of the chemicals derived from *Belladonna*. Atropine is found both in the berries and the leaves of *Belladonna* and will disrupt the parasympathetic nervous system, which causes a disruption of involuntary activities such as sweating, breathing and heart rate. The antidote to atropine poisoning (such as eating the berries or leaves of nightshade or by overdose) is pilocarpine[73].

Among atropine's many uses including acting as a counter agent to poisons such as organophosphates and nerve gases (Sarin and VX). Atropine's antidote effects are due to the physiological effects which are to increase heart rate and block acetylcholine receptor sites. So, atropine can be both a poison (when overdosed) and an antidote to a different poison.

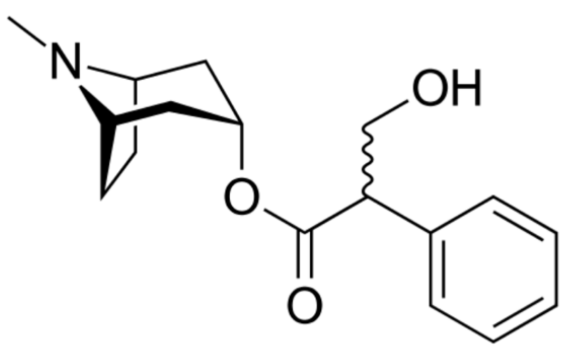


Figure 4.07 Structure of Atropine Courtesy of Wikipedia.org

Figure 5: Excerpt of textbook page from Game of Thrones chapter from the Chemistry of Movies and TV by Sean Hickey. Textbook available at TopHat.com

Medicine/Poisons

- There are medicine, drugs and poisons in Game of Thrones.
- More advanced than the equivalent "medieval times" in our history.
- But all of them are grounded in real world examples.

Video #31

Essence of Night Shade

Video #32

- In our world *Atropa Belladonna* or Belladonna or Deadly Nightshade is a plant found in Europe, No. Africa and Asia.
- The leaves and berries are toxic causing delirium and hallucinations.
- Atropine and scopolamine (patch for motion sickness) is derived from this plant.
- Atropine many uses including counter agent to poison. Increases heart rate and blocks acetylcholine receptor sites.
- Belladonna berries are lethal at a dose of 2-5 berries or one leaf.
- Physiological effects include blurred vision, tachycardia, loss of balance, staggering, headache, dry mouth and throat, slurred speech, hallucination, delirium, convulsions.
- Atropine in the berries and leaves disrupt the parasympathetic nervous system and this disrupts involuntary activities such as sweating, breathing and heart rate.
- Antidote is pilocarpine.

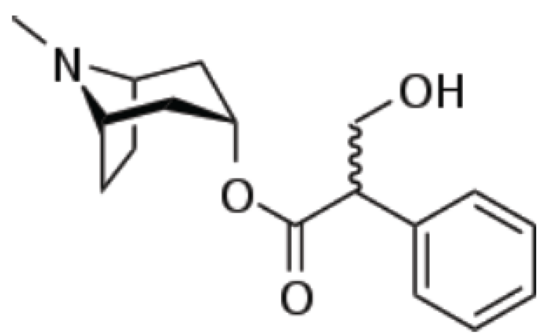


Figure 6: Excerpt of student notes from the Nightshade lesson of the Game of Thrones chapter.

Slides 30-37, Medicines and Poisons, 45 minutes

Video #36, 3 minutes, Sarin Gas scene from the Rock.

Slide 30, Overview of Medicines in GOT

Video #31, 2 minutes, overview of medicine, drugs and poisons

Video #32, 3 minutes, Cersei has taken all of the women and children into the Red Keep to protect them from the invading army from Stannis (Slide 17, Video #17). She is prepared to kill everyone with Essence of nightshade rather than let them be kidnapped (tortured and possibly raped) by Stannis's soldiers. Nightshade is used to calm frayed nerves (one drop), to induce deep sleep (3 drops) or to cause death (10 drops).

Slide 30 (continued), summary of the real-world nightshade, where it comes from and what it does

Video #33, 1 minute, explanation of neurotransmitter

Video #34 OR 34, 13 minutes or 5 minutes, #34 (Chemical Weapons) is 13 minutes and includes cuts back and forth from Professor Poliakoff and Stockman. Poliakoff talking about his father's gas mask and chemical test kit while Stockman talks about Sarin gas. #34 (Sarin) is 5 minutes and is edited to only show Dr. Stockman's Sarin gas explanation. I would opt to show the edited 5-minute version (and let students know that the full video is on Top Hat). The video is a great video explaining how the NT work and how Sarin attacks the acetylcholinesterase enzyme.

Video #35, 4 minutes, SciShow video explaining Sarin gas

After 2 videos, just recap and explain the NT and how it works.

Slide 31, summary of the chemistry of NT, Sarin and how it works

Recap of Video #36, 3 minutes, Sarin Gas scene from the Rock. The BIG thing wrong is they want the person to stab a needle into his HEART. NO!!! that is not how it works. No one but the most skilled surgeon will put anything into the heart. All you do is inject in a vein. Atropine is a short-term antidote to Sarin. It will compete with acetylcholine and temporarily help against Sarin until Pralidoxime reactivates the acetylcholinesterase enzyme

Video #37, 1 minutes, also from the Rock, showing the dangers of VX. VX is fatal and is a heavy oily liquid like in the video clip. But it won't cause the dermatological damage seen in the clip

Video #38, 2.5 minutes, famous pulp fiction clip, NOT atropine but adrenaline for OD. Just to show this has become a TROPE. The big-needle shot to the heart which is WRONG!!

Figure 7: Page 1 of instructor notes from the Nightshade lesson of the Game of Thrones chapter.

Do not show both 39 and 40, just show one of the two (probably 39)

Video #39, 7 minutes, Periodic table video about VX and sarin.
I would show the shortened version of #34 (5 minutes NOT 13 minute) and then show video #39 (and NOT #40, which is a bonus video about 2-stage VX weapons and is on Top Hat).

Video #40, 4 minutes, bonus video about 2-stage VX weapons.

In Top Hat textbook, there is a discussion about the 2-stage VX poison used to kill Kim Jung Un's half-brother (N. Korean dictator). You can mention this briefly and refer them to Top Hat.

Video #41, 4 minutes, how nerve agents were discovered/made by Nazi Germany

Just summarize this video.

https://moviepilot.com/p/vx-nerve-agent-the-rock-and-political-assassinations/4227358

This link above has some information on the Rock, VX and the assassination of Kim Jung Un's half-brother

17-POD-Harry Potter-2 minutes

1. Atropine cures Sarin gas attack, which causes your muscles so they are always contracted and/or extended like you are petrified. So it makes sense that Atropine cures the real-world poison Sarin, which "petrifies" your muscles, then it should cure magical "petrification" also
2. Gloves, lab coats, goggles
3. Gloves and lab coats but not goggles

Ignore the bonus unless you talked about Tropes.

Slide 32, **SSRI** (selective serotonin reuptake inhibitors). Not in GOT but to show more about NT. Sarin gas is a **POISON**. It works by inhibiting the enzyme that destroys/regenerates the excess NT, acetylcholine. So Sarin inhibits the enzyme and that produces a bad result so we call it a poison.

Prozac and other SSRI are drugs. They also inhibit an enzyme, SSR (selective serotonin reuptake enzyme), that is responsible for removing/regenerating serotonin NT from the synapse. Prozac inhibits that enzyme but it produces a good result, relieves depression so it is a drug.

Point here is to make them understand that a poison is a drug and a drug is a poison. They both interfere with a bodily process, the drug does it for the good of the body and the poison does it to the bad of the body.

Quite often we can take that poison and make it a drug. Cone snail venom/toxin is a poison that is now being investigated as a potential pain drug. Mustard Gas a poison in WWI is being investigated as an anti-cancer drug. Derivatives of Sarin may someday be used as a drug.

Video #42, 1.5 minutes, overview of SSRI

Figure 8: Page 2 of instructor notes from the Nightshade lesson of the Game of Thrones chapter.

Table 8: List of all videos shown during Nightshade lesson of the Game of Thrones chapter.

Video # and Title	Source	Length	Synopsis
31-Raycelle Burks on Poisons, Medicine …	ACS Reactions YouTube https://www.youtube.com/watch?v=kb-XDGcAuLM	1:54	Quick video about poisons and drugs,
32-Essence of Nightshade	*Game of Thrones* (GOT) Season 2, Episode 9, courtesy of HBO	3:02	Scene where Cersei is about to poison her son
33-CLD Inc. - Neurotransmitter	Customlearningdesign YouTube https://www.youtube.com/watch?v=aMzOKpF0zuQ	1:09	Overview of neurotransmission
34-Sarin	Periodic Table of Videos YouTube https://www.youtube.com/watch?v=jozozH09XSs	12:52	How sarin gas works on neurotransmitters
35-What is Sarin Gas	SciShow YouTube https://www.youtube.com/watch?v=w3sJEbcT7IE	3:56	Overview of sarin gas
36-The Rock Lab Scene	*The Rock* courtesy of Buena Vista Pictures	3:56	Scene where a suspected sarin gas crate is opened
37-The Rock VX	*The Rock* courtesy of Buena Vista Pictures	0:51	Scene showing the effects of VX gas
38-Shot of Adrenaline – *Pulp Fiction*	MovieClips YouTube https://www.youtube.com/watch?v=ZOoJoTAXDPk	2:42	Scene showing the shot of adrenaline to the heart
39-VX nerve agent	Periodic Table of Videos YouTube https://www.youtube.com/watch?v=62fPW-5TR-M	7:11	Overview of VX gas
40-VX and Binary Weapons	Periodic Table of Videos YouTube https://www.youtube.com/watch?v=n7uJoi8DXiA	3:59	How VX gas can be a binary weapon
41-How the Nazis invented agents	ACS Reactions YouTube https://www.youtube.com/watch?v=3te1o6dYmLI&t=14s	4:11	Overview of nerve agents
42-How do Antidepressants work	Bogdan Paul YouTube https://www.youtube.com/watch?v=G4r3qCkLUDQ	1:54	Overview of NT and serotonin
POD3-Mandrakes in Herbology	Wizarding World YouTube https://www.youtube.com/watch?v=G17jQg_pUJg	2:04	Scene from herbology class

The lesson on biochemistry (via Essence of Nightshade poisoning) uses 13 videos in class, which are summarized in Table 8. For the *Game of Thrones* chapter, there are over 70 videos, most of which are shown in class during the two to three weeks spent on this chapter. The videos are also loaded on TopHat for students to view and for other instructors to use.

3.3 Dr. Stanly Goodspeed + Queen Cersei + Pac-Man – Pulp Fiction = Neurotransmitters

Math can be fun and educational. But, does this equation really add up to an understanding of neurotransmitters? Yes, it does. But it takes a little creativity to wrangle the facts and the media together to bring forth a compelling lesson. Luckily, much of the hard work was done already by Hollywood (*Game of Thrones, The Rock, Pulp Fiction*) and the fine folks at ACS Reactions, Periodic Videos and SciShow YouTube channels. Before all is done, *Breaking Bad* and *Harry Potter* will join this lesson and make for a strange, unexpected concoction that somehow forms a very unlikely but fantastic lesson.

The lecture started with a scene from *The Rock* about a sarin gas attack. After this video, the class is NOT explained the science in the clip but are told that they will understand it throughout the lesson. The next part of the lesson was to go over the use of medicines and poisons in *Game of Thrones*, starting with the Essence of Nightshade and how it is used to calm nerves, induce sleep or cause death.

Next, the students are shown the videos from ACS reactions (#31, Table 8) and a clip from *Game of Thrones* where Cersei is about to poison/kill all the women and children rather than let them be kidnapped, raped and/or killed (#32, Table 8). In the ACS reactions video, Raychelle Burks explained how chemists say, “The dose makes the poison”. The students are asked to make special note of this because it will be important regarding the chemistry of atropine.

Next, the students will be explained the chemistry (and biochemistry) of the real world-equivalent of Nightshade, which is *Atropa Belladonna* or Deadly Nightshade. They will be told about the toxicity of Nightshade and the alkaloids contained in Nightshade, which are atropine and scopolamine. Atropine is toxic and can be fatal when ingested in a high enough dose, which leads back to a main point of the lesson, “the dose makes the poison”. Other chemicals that are poisonous by their dosage, such as water or formaldehyde can also be introduced.

At this point, the lesson transitioned to a discussion of neurotransmitters. First, students were shown a video about neurotransmitters (#33, Table 8), which is followed with a discussion on how neurotransmitters work. Next, two amazing videos from Periodic Videos (#34, Table 8) and a SciShow video (#35, Table 8) were shown. The Periodic Videos video is almost 13 minutes long and transitions back and forth from Professor Poliakoff talking about his father’s gas mask and chemical test kit from WWII while Professor Stockman is talking about the toxicity and mode of action of sarin gas. An edited version of the video is available that only showed Professor Stockman’s portion of the video. The edited video is shown in class, but the full unedited video is available in the interactive textbook.

In the edited video, Professor Stockman gave a quick but comprehensive model of neurotransmitters and how acetylcholinesterase is responsible for clearing acetylcholine out from the synaptic cleft of the neuromuscular junction so that muscles can relax. Professor Stockman explained how sarin bonds to the enzyme acetylcholinesterase, the Pac-man™ molecule, and prevents muscles from relaxing. Thus, your arm was always flexed or in the case of sarin gas, your lungs cannot relax. This leads to the gasping for air and eventual death for the individual who was exposed to sarin gas. Professor Stockman explained how sarin is a small molecule, so it exists in gaseous form. He also explained about the fluorine in the sarin gas and how it bonded covalently to the enzyme, effectively shutting off the enzyme. This allowed for a good discussion on intermolecular forces, boiling point and melting points as well as covalent bonding, fluorine reactivity and uses in medicine. Students will revisit the chemistry of fluorine when the class discussed the incorrect method (HF, hydrofluoric acid) that Walter White uses to dispose of bodies in *Breaking Bad*.

As the video explained, there is an antidote for sarin gas. So, after the video, there was a recap of neurotransmitters and then a discussion about the antidote for sarin gas. After a sarin gas attack, the first antidote that is given usually is atropine. Atropine competes with acetylcholine at the receptors. By flooding the system with atropine, acetylcholine will be removed from the receptors and muscles (lungs) will relax. This is only a temporary fix because the synaptic cleft is flooded with acetylcholine. Pralidoxime is the other antidote that is administered. Pralidoxime helps reactivate the acetylcholinesterase, which then clears the synaptic cleft of acetylcholine.

Although this was a fairly dense amount of information, it led into a good discussion again about how atropine is toxic at certain doses (and circumstances). But atropine can also be an antidote for sarin gas at other certain dosages (and circumstances). Students were also told how the difference between a drug and a poison is just semantics. If a chemical is ingested and does something beneficial, it is a drug. But if a chemical is ingested and does something harmful, it is a poison. Often the drug and the poison are doing the same thing in the body, such as shutting down an enzyme, but the physiological results are much different.

At this point, the scene from *The Rock* (video #36, Table 8) was revisited. The students were told the writers had the science right about how sarin works. They had also correctly identified atropine as the antidote (or one of the antidotes) for sarin gas poisoning. But they were DEADLY wrong about how the atropine needed to be injected directly into the heart. Atropine needs to be injected into a vein NOT the heart. Only trained professionals (and in very rare circumstances) should ever think about injecting anything directly into the heart. When needed, it is done very carefully and under supervision. It is **NOT** done by stabbing a needle into the heart willfully.

Next, a scene is shown from *Pulp Fiction* next (video #38, Table 8). This is the famous scene where Uma Thurman is overdosing, and Eric Stoltz shows John Travolta how to inject the adrenaline directly into her heart by plunging the needle as hard as he can to break through the breastplate and inject into the heart. WRONG ON SO MANY LEVELS!! Can a needle break through bone? No, even if it could, the bone would deflect it and would miss the heart. If the heart was hit, it will tear a hole in the heart…Is that a good thing? This is a good point to show students how movies like to use, reuse and overuse devices like this to tell a story. This is what is known as a movie or TV trope.[131] Tropes like this are why anytime a chemistry lab is shown in a movie (without a science consultant), the chemicals are all blue and red and boiling with smoke billowing everywhere.

Time permitting, videos on VX nerve agent (#37, 39, 40, Table 8) were shown. VX is also part of the plot of *The Rock*. The writers again have some of the science information about VX correct, but vastly overexaggerated the dermatological face-melting effects of VX. The really interesting thing about VX (and the Periodic Videos video I show) is how VX is thought to have been used in the assassination of Kim Jong Un's (North Korean dictator) half-brother. This topic is great because it can show how two substances on their own that are not dangerous can be mixed together to create a very dangerous substance. It is theorized that the assassination was carried out by duping two females to separately swab a liquid on the victim. Each liquid on their own were innocuous but mixed they produced VX, which killed him. Next, the students were shown a SciShow video (#41, Table 8) about how these nerve agents were made in Nazi Germany. If there was not time, the students watched all of these videos on their own from the interactive textbook.

What is so great about this lesson plan is how different movies and lesson are threaded together to build a bigger lesson AND force the students to synthesize knowledge together to answer questions. This method of teaching is often referred to as framing or scaffolding[133,134] pedagogy.

The lesson started with a clip from *The Rock* and then went into use of poisons in *Game of Thrones*. From there, an introduction to "dose makes the poison" was followed by detailed explanations of neurotransmitters and sarin gas. Next, the film tropes about "needle to the heart" were followed by VX gas, binary poisons and history of nerve agents. The students were exposed to a ton of material, but a special emphasis was placed on how neurotransmitters work and how drugs/poisons can affect those neurotransmitters. Student saw how atropine (a drug and a poison) can displace acetylcholine and temporarily stop the effects of a sarin gas attack. If the lesson had been carried out effectively, students should be able to synthesize that knowledge to answer a question on a topic about neurotransmitters they have not seen before.

Next, students were given a POD (problem of the day) to the students. The POD was usually a “thinking” question that relates to the day’s lesson or sometimes was just a question to get them to think critically. At the end of the *Game of Thrones* lesson (this may be the end of that day lecture or the start of next lecture), students were shown a clip from *Harry Potter and the Chamber of Secrets* (POD3, Table 8). In the clip, the students at Hogwarts were shown taking a herbology class under the direction of Professor Sprout, who is showing them how to repot Mandrake. In the scene, Neville Longbottom was knocked out by the scream of the juvenile Mandrake. After the clip, the students are given the following POD (Figure 9).

POD-Harry Potter and the Chamber of Secrets:

Mandrake, aka Mandragora, is a plant whose root looks like a human. When exposed, the root will scream. An immature plant will knock you out for a few hours. A mature Mandrake’s scream can kill.

Mandrake root is used to make the Mandrake Restorative Draught. This draught is used in this movie to restore those who have been petrified from the Basilisk.

Mandrake tubers are real plants. They are a member of the Deadly Nightshade (Belladonna) family. Extracts of Mandrake contain Atropine and Scopolamine just like Deadly Night shade.

When your eyes make contact with the Basilisk’s eyes, you are petrified (similar to Medusa in Greek mythology).

1. Using what you know about Atropine, propose why Mandrake would be a cure for being petrified by the Basilisk.

2. In the clip, they wear earmuffs to protect their ears from the Mandrake scream, this is called PPE (personal protective equipment). What PPE do you imagine chemists where in labs to protect them?

3. What other PPE were the student from Harry Potter wearing while working with these plants?

BONUS:

We talked about Tropes last week in class. Give an example of a Trope and at least two pieces of media where it occurred.

Figure 9: Copy of POD#3 from Chemistry of Movies and TV class.

A good student will recognize that a sarin gas attack causes the muscles to always be “on”. If their arm is extended, it will stay extended. If their breathing out, they stay breathing out. It is like they are petrified, stuck in that muscle contraction. If they are petrified by the Basilisk, maybe that is some sort of “sarin” like attack on their neurotransmitters. So, if atropine can clear off the acetylcholine from the receptors following a sarin gas attack, then Mandrake Restorative draught (made from a plant in the Nightshade family), probably contains atropine or a similar compound and can serve as an antidote to being turned to stone.

This question can be modified to give the students more or less hints depending on the level of the class. If this were an upper level biochemistry class, they would be just shown the video clip and asked, “Using what you have seen in this lesson, propose how Mandrake can be a cure for being petrified by the Basilisk”. For the nonscience majors class, they are given the questions as seen in Figure 9.

During the next lecture, there was a discussion of the use of selective serotonin reuptake inhibitors (SSRI, such as Prozac). Just as atropine can be a poison or a drug, the students learned that removing an enzyme that degrades neurotransmitters can be toxic (sarin destroying acetylcholinesterase) or beneficial (SSRI neutralizing SSR to flood synaptic cleft with serotonin). This level of understanding was so important for students. Students needed to understand that in medicine (but in many other things also) doing something will not always have the same outcome depending on where, what, how and when it is done. Shutting off an enzyme can be very bad (sarin) or can be very beneficial (SSRI). Drugs can be used to increase neurotransmitters or decrease neurotransmitters as needed. Enzymes can be deactivated (SSRI) or activated (pralidoxime). Students needed to understand that knowing how a biochemical pathway in the body works can allow scientists to both increase or decrease that pathway at any step in the pathway depending on the need. This is one of the tenets of medicinal chemistry.

At this point, students have seen two examples of drugs affecting neurotransmitters. In subsequent lectures, the students were shown how dopamine affected brain chemistry in Parkinson's (using *Awakenings*, Muhammad Ali and Michael J. Fox). Later in the semester, they were introduced to *Breaking Bad* and how neurotransmitters are affected by drugs, such as methamphetamines. The lesson on neurotransmitters spiraled around again and again, each time reinforcing what the students needed to know. These POD were used throughout the semester including the very first day of lecture. At the end of the very first lecture, they were shown a video from *The Hobbit: The Desolation of Smaug* where Smaug was breathing fire[135] And were asked to explain what they saw (see section 2.2).

3.4 In Conclusion

In the end, has the "math equation" (Dr. Stanly Goodspeed + Queen Cersei + Pac-Man – Pulp Fiction = Neurotransmitters) been proved? Does *the Rock, Game of Thrones,* Periodic Videos and SciShow YouTube videos minus the bad trope from *Pulp Fiction* lead to an understanding of neurotransmitters? How effective was this as a teaching method?

There are six semesters of data that shows it was fairly effective as summarized in Table 8. The performance was notable because in spring 2014, fall 2014, fall 2017 and fall 2018, the intensive lesson on neurotransmitters was not used and understanding of neurotransmitters was poorer than in the two semesters (fall 2015 and fall 2016) when it was used fully. Although the fall 2017 and fall 2018 data may not be as useful (see below).

Data for the first four semesters is most important since all four semesters were taught by the same professor. During the spring 2014 and fall 2014 semesters, a traditional lecture format was used without all of the videos. During the fall 2015 and fall 2016 semesters, the video intensive lecture style (VILS) was used. The data for the first four semesters seemed to indicate that students did much better in the fully immersive lecture, average = 88.5%, versus the traditional lecture, average = 67.5%, (Table 9). A 31% improvement in scores on "thinking" questions were seen on exams in the VILS (fall 2015 and fall 2016) versus the traditional lecture format (spring 2014 and fall 2014).

In fall 2017, an adjunct taught the course for the first time and had very little time to prepare. The adjunct used a partially interactive format when teaching this lesson. But since it was the first time teaching this course and within the first couple of weeks of teaching it, the results are not clear. There are some interesting possibilities though as seen in Table 10 and discussed in the future work section.

Fall 2018 was taught by a different instructor who was given the course one day before classes started. Because of this and other reasons, that adjunct did not cover the *Game of Thrones* unit in class but instead made the students read it and watch the videos from the chapter. Also, assessment was done solely by attendance, in-class quizzes and questions and out of class projects. A direct correlation cannot be made. Only anecdotal analysis of student performance in the class and student evaluations can be used. But on a very tentative and non-scientific level, the class overall had a very poor performance on thinking questions. No data is available at the time of this chapter only the impressions from the instructor.

Because of this, the fall 2017 and fall 2018 data is seen as incomplete and does not offer substantial value to this discussion. So only the first four semesters were seen as significant for analysis on student performance. However, a comparison of POD performance from fall 2015/2016 to fall 2017 show a significant drop in POD performance when VILS is not used (fall 2017) compared to when VILS is used (fall 2015/2016).

Table 9: Analysis of POD and thinking questions on exams from the six semesters that this course has been taught.

Semester	Number of Students	Teaching Method	Performance on POD3	Exam Performance[4]
Spring 2014	74	Traditional	N/A[1]	Average (61%)
Fall 2014	97	Traditional	N/A[1]	Average (74%)
Fall 2015	118	Interactive	87%	Excellent (89%)
Fall 2016	78	Interactive	87%	Excellent (88%)
Fall 2017	87	Interactive	71%[2]	Average (79%)[5]
Fall 2018	101	Textbook only	N/A[3]	Below Average[6]

1. Spring 2014 and Fall 2014 did not have a POD on neurotransmitters.
2. In Fall 2017, an adjunct taught the course and covered *Game of Thrones* but did not do the extensive coverage and the scaffolding.
3. In Fall 2018, an adjunct taught the course and did not cover *Game of Thrones* in lecture. Instead had the students read the units in the textbook.
4. Data is based on exam performance on all thinking questions (not just neurotransmitters) for exams. Analysis of neurotransmitter questions has not been done yet.
5. Two exams had thinking questions but the third was all multiple-choice. Only the two exams with thinking questions are summarized in the exam performance category. A partially interactive methodology was used, and course was taught by an adjunct who had never taught a course like this and had very little time to prepare before the semester started.
6. Exams were not used in Fall 2018 course. But performance overall in the class on thinking questions (in-class quizzes) were way down this semester. This is all anecdotal since the data has not been compiled yet from the instructor who taught the course. However, his class averages were way lower and student evaluations were not good, but that could be due to difference in teaching methodology and many other factors.

3.5 Future Work

The fall 2017 course does offer some interesting possibilities for future work. There was an online cohort (fall 2016 also had only a small online cohort that took the test in person on campus) that watched recordings of the in-class lecture and completed all their work online, including tests. Since the tests were done online, analysis of individual neurotransmitter questions can be done easily. Figure 10 shows the neurotransmitter questions from the online cohort's exams. The analysis of question and exam performance is compiled in Table 10.

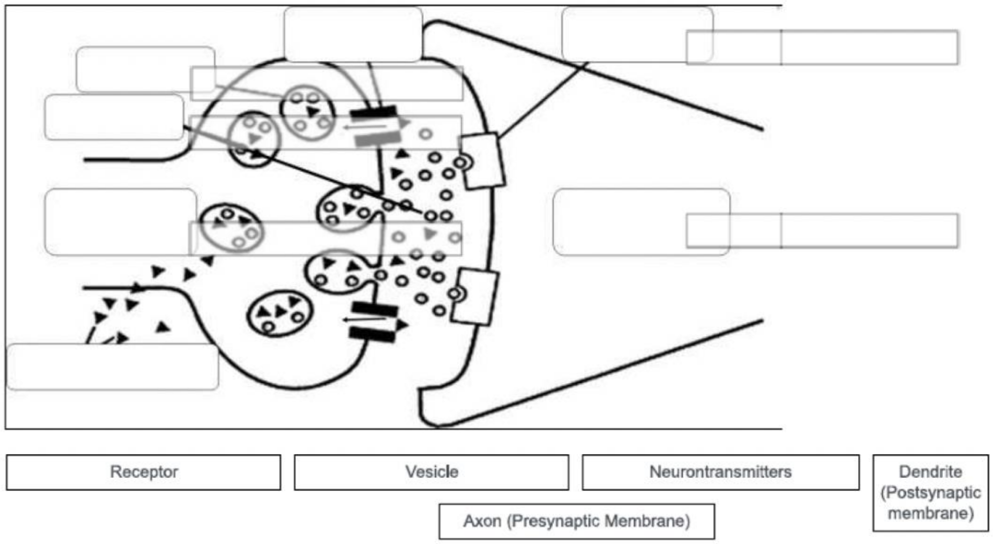
Question #38, which is a more straightforward memorization questions, showed an excellent 87% success rate. While questions #39, 40, 41 and 50, showed much poorer results. These questions required a higher level of thinking for the students. The data covers only the cohort of online students, since the traditional exam has not been analyzed on a question by question performance.

A question by question analysis of each in class exam is underway. The hypothesis is that the performance on the higher-level thinking questions will be better when an intensive, interactive format were used instead of a traditional lecture. Comparison of the in-class cohort versus the online cohort could also be done. Additionally, a comparison of students who were present for the intensive *Game of Thrones* lecture versus those that were absent can also be performed. Full data analysis of these (and other data points) could be performed and reported.

Question 38

Not yet answered   Marked out of 5.00

Drag and drop the labels to their appropriate place.



Question 39

Not yet answered   Marked out of 5.00

Briefly explain the action that occurs in the synaptic cleft of a normal nerve cell.

Question 40

Not yet answered   Marked out of 5.00

If a disease is caused by an excess of neurotransmitters, explain what a drug would do to lower the amount of neurotransmitters.

Question 41

Not yet answered   Marked out of 5.00

If a disease is caused by a deficiency of neurotransmitters, explain what a drug would do to increase the amount of neurotransmitters.

Question 50

Not yet answered   Marked out of 16.00

Explain the two ways that methamphetamine increases dopamine in the synaptic cleft.

Figure 10: Neurotransmitter questions from online cohort exams.

Table 10: Analysis of POD and thinking questions on exams from the six semesters that this course has been taught.

Course	Number of Students	Question Number for Online Exam	Performance on Question	Exam Performance
Traditional	112	N/A	N/A	79%
Online	14	38	87%	83%
Online	14	39	66%	83%
Online	14	40	63%	83%
Online	14	41	63%	83%
Online	10	50	52%	83%

1. All online questions came from the same online exam, so the comparison to exam performance (83%) will be the same for all of these questions (38, 39, 40, 41 and 50).

The neurotransmitter lecture was not the only intensive, active learning lecture in the class. There were many other topics in *Game of Thrones* (wildfire, genetics, illness), *Breaking Bad* (drug production, HF disposal of bodies, phosphine, magnets, dilution…), superhero chemistry, *Jurassic World…*that could be analyzed. Additionally, work has been started on a group exercise where students will play the parts of the neurotransmitters, vesicles, receptors….to gain an even better understanding of how neurotransmitters work. Analysis of these topics could also be considered.

Chapter 4 Pedagogical Approach for CHEM 1002

4.1 An Example of a Short Video Intensive Lecture for CHEM 1002:

In a faculty-centered, traditional lecture, the material of the lecture is disseminated in a method such that all of the students attention is centered (or concentrated) on the faculty disseminating the information to the students who are listening but not participating. A traditional lecture approach to teaching subatomic particles might start like this:[136]

If you look at the periodic table, you will see that it is composed of individual boxes. There are numbers, letters and words in each box. The top number is the atomic number, which identifies the element and gives the number of protons and most often the number of electrons...

This is the not the most exciting way to start a lecture and can quickly lose even a motivated student's attention. Now imagine a business major or English major in their first college science class. This is a recipe for disaster. Students will disengage and potentially never come back.

Usually, the subatomic particle lesson in CHEM 1002 started with a quick 1-2 minute traditional "lecture" as seen above. Afterwards, students were asked "Did you understand that? Was it exciting? Will you remember it?". Most often students would shrug or maybe honestly answer "No". They were then shown a clip from *WKRP in Cincinnati* as an alternate teaching approach. Episode #12 of Season 3, "Venus and the Man", has DJ Venus Fly Trap going back to his roots as a teacher to explain how the atom works to a student threatening to drop out of high school. Here is a quick synopsis of the clip from episode #12:

The clip opens with Venus Fly Trap (played by Tim Reid) telling Arnold (played by Keny Long) that he needs to stay in school. Arnold says he doesn't understand anything the teachers are talking about in class. Venus asks, "What about chemistry?". Arnold replies "That is the hardest one". Venus then says he can give him the basics of the atom so that Arnold will understand it perfectly and remember it for months and all he needs is two minutes. He bets that if he can do this in two minutes then Arnold will not drop out of high school.

Venus starts by explaining there are three gangs and then he draws a big circle. He calls this the neighborhood, which is block after block of nothing. The first gang is in the very center of the neighborhood. They are called the New Boys. The Elected Ones are the gang on the very outer edge of the neighborhood. They are very negative dudes and all they do is circle around the neighborhood checking on the New Boys. The New Boys see this, and they figure something is wrong and they make a deal with the third gang, the Pros. The Pros are very positive cats. The Pros and the Elected ones hate each other. So, they always keep the exact same number of people in the gangs. "Just in case, you dig?" So, if there are 10 elected ones, how many Pros are there?

Venus then quizzes him on the number of gangs, their names, are they positive or negative, where they hang out, how many members are in the Pros and the Elected Ones. Arnold answers all the questions. Venus then tells him the Pros and the New Boys hang out is right in the center and it is called the "Nucleus". Venus says he thinks it might be Swahili (just to get Arnold interested). In Swahili (not true), it means center. Venus says there is another Swahili word called "tron", which means dude. All the gangs like it so much that the Pros started calling *themselves "Protons" (not* ***protrons****, but he has Arnold's attention). The New Boys call themselves "Neutrons" and the Elected Ones call themselves…Arnold answers "Electrons".*

Arnold says your time is up and he says, "Man, all I know about is a bunch of damn gangs that live in a round neighborhood". Venus says, "That's the atom, that is it". He then quizzes him through all the parts of the atom and Arnold realizes he knows the atom.

This video usually gets some good laughs and even some realizations that they will remember all these things about the atoms because they relate to this approach of teaching. The advantages of using videos in the chemistry lecture is well documented.[61-64] Pedagogical advantages of using videos[137-139] include findings that using videos can explain highly complex ideas in a simple, short video,[140] visual media makes concepts more accessible[141] and helps students retain concepts and ideas.[142]

In Spring 2015, a traditional lecture approach was used for explaining atomic structure followed by a question on atomic structure. After the in-class question, the video from *WKRP in Cincinnati* was shown and students really responded well to the video. Due to the poor performance on the quiz that spring, the format of the lesson was changed. For Spring 2016, 2017 and 2018, the short traditional introduction was followed with the video from *WKRP in Cincinnati*. Next, a follow up lecture with a 5-minute discussion about the video and more information about counting electrons, neutrons and protons in atoms, ions and/or isotopes was given. The in-class question or assignment followed after the complete lecture. Student understanding of the material was greatly increased with this new format.[143] The information from the four semesters of the course is included in Table 11.

Table 11: Quiz Average on Atomic Structure for CHEM 1002 (Spring 2015 to Spring 2018).

Quiz Average (Atomic Structure)			
Semester	# of Students	Quiz Average	Notes
Spring 15	54	57%	Quiz was before WKRP video
Spring 16	85	83%	Quiz was after WKRP video
Spring 17	52	93%	Quiz was after WKRP video; 3 questions
Spring 18	76	86%	Quiz was after WKRP video; 3 questions

Students were surveyed on many of the videos in class to determine how they rated the effectiveness of each video.[144] In spring 2016, for the *WKRP in Cincinnati* video, 69% of students who responded stated that the video was both entertaining and effective at explaining the science. 19% of students thought the video explained the science but was not entertaining. 8% of students thought the video was neither entertaining nor did it explain the science well. 4% of students thought the video entertaining but did not explain the science well (Figure 11).

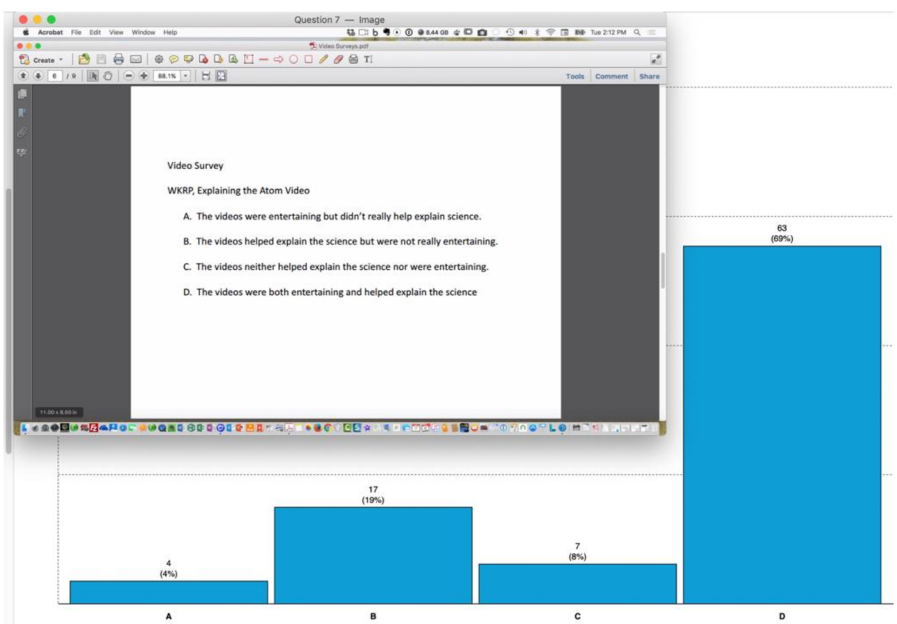


Figure 11: Survey Results of the Effectiveness of WKRP in Cincinnati Video from Spring 2016. Poll taken using iClicker Reef Polling.

4.2 An Example of a Multi-Day Video Intensive Lecture in CHEM 1002

A nonscience major course, where all structure and constraints of a typical general chemistry course are discarded, allows for complete flexibility in creating lessons and no need to follow a set course, where one topic is used to build on another topic. Instead, the flow of the course can be dictated by other patterns. In CHEM 1002, the course is divided into three main units (Life, the Universe and Everything). The lesson describe here is from the universe unit. The lesson represents much initial work plus retooling and adding and removing of videos to get to the final lesson that was presented in the spring 2018 course.

The universe unit was broken down into three subunits. The first subunit was basic chemistry concepts, which focused on atomic structure, states of matter, gas laws and so forth. The second subunit was energy and the universe, which focused on the size and complexity of the universe (atmospheric composition of various planets), the sun as a source of energy, sources of energy and nuclear power and weapons. The last subunit was environmental chemistry and focused on climate change and ozone layer depletion (in the future, recycling and green chemistry will be added).

Environmental chemistry usually takes just under 3 lectures with climate change usually taking two lectures to cover and ozone depletion usually taking most of one lecture to cover. The climate change lesson started with a clicker quiz that is shown in Figures 12-16. The purpose of the quiz was to:

- determine the baseline of student knowledge about climate change
- to get students to think critically
- to get students interested in the topic

1. Do you believe in man-made Global Warming?

A. Yes

B. No

C. I don't know

Figure 12: Climate Change Question #1 for CHEM 1002. Subjective question, no correct answer. 84% yes, 11% no and 4% I don't know (total # of students = 45).

2. What causes global warming?

A. Earth's orbit

B. Greenhouse Gases

C. Solar activity

D. Variations in Earth's tilt

E. Human activity

Figure 13: Climate Change Question #2 for CHEM 1002. All of the answers are correct. 0% A, 80% B, 2=4% C, 0% D and 16% E (total # of students = 43).

3. Where is there less instantaneous local warming?

A. New Orleans

B. Seattle

C. Miami

D. New York

E. Phoenix

Figure 14: Climate Change Question #3 for CHEM 1002. Phoenix is correct. 18% A, 29% B, 16% C, 7% D and 31% E (total # of students = 45).

4. When was the last time the global temperature was below the 20^{th} century average?

A. July 2012

B. September 2001

C. December 1984

D. December 1972

E. July 1969

Figure 15: Climate Change Question #4 for CHEM 1002. December 1984 is correct. 11% A, 13% B, 41% C, 28% D and 7% E (total # of students = 54).

5. Are Weather and Climate Change the same?

A. Yes

B. No

C. I don't know

Figure 16: Climate Change Question #5 for CHEM 1002. No is correct. 5% yes, 95% no and 0% I don't know (total # of students = 55).

NOTE: All questions are being changed to use Climate Change instead of Global Warming for future classes.

Looking at the quiz results from 2018, 84% of the class believed global warming is manmade compared to 87% of members of the American Association for the Advancement of Science and 50% of the general public according to 2015 Pew Research Center survey.[145] It is encouraging that the students seem to be more aligned with scientists than the general public. Question 2 is interesting because students definitely make the connection that Greenhouse Gases (80%) and human activity (16%) affect climate change but miss the other factors that affect climate change.

Question 3 allows for a discussion of the effect of water vapor as a greenhouse gas. In places with low humidity, such as Phoenix, there is very little water vapor in the air. The water vapor in air traps infrared radiation and contributes to instantaneous warming at night. At night, without sunlight to provide direct heating and without water vapor to trap heat, deserts can become very cold. During the day, there is no water vapor to trap the cold air from the night, so deserts get very hot with the rising sun.

Question 4 is a logical question. Students should infer that the last time the monthly temperature average would be below the 20th century average would be during the winter months. Students had December 1984 and December 1972 as their top choices, which makes logical sense. December 1984 was the last month to have an average temperature below the 20th century average.[146,147] Question 5 is very encouraging. 95% of the students realized that weather is not the same as climate change.

After the quiz, a few minutes were spent lecturing about the basics of climate change using some infographics and videos from Its Okay to Be Smart's YouTube channel[148,149] and Kurzgesagt's YouTube channel.[150] This takes about 30 minutes (videos occupy about 20 minutes of that time) but gives a very good base knowledge of climate change to the students. The infographics and videos are very well-done and provide a professional overview of climate change. The next 30 minutes of lecture are spent explaining the videos and going over the more technical aspects of climate change, such as what are greenhouse gases, how does CO_2 absorb IR radiation, CO_2 levels throughout the year, using ice core samples to determine pre-historic CO_2 levels and more.

After those 30 minutes of less entertaining material, student's attention started to waver a bit, so an entertaining (yet informative) video was played next for the students. The students were shown a video clip from Napoleon Dynamite.[151] In the video, Napoleon is competing in the Future Farmers of America competition where he is diagnosing what is wrong with samples of cow's milk. The second sample's defect is the cow got into an onion patch and Napoleon could taste the onion in the milk. So, what does this have to do with climate change?[152] Up to 11% of greenhouse gases comes from methane and up to 20% of that methane comes from the flatulence, belching (majority of methane comes from belching) and defecation of ruminants such as cows. Evidence has been presented that adding garlic or onion to a cow's diet can decrease the amount of methane released by cows by changing the chemistry of the rumen. But one of the issues with adding garlic or onion to a cow's diet is that if you add too much, the milk will taste like onion or garlic. If too little is added, it will not be effective. Therefore, the scene with Napoleon tasting milk to detect for the taste of onion actually does relate to global warming. The first lecture period ended after this video and explanation.

The second lecture focuses more on politics and the battle over climate change. The lecture started with a video from Yale Climate Connections[153] discussing the documentary, *Merchants of Doubt*.[154] This documentary explains how the same tactics that tobacco lawyers used to attack the scientists who said smoking was bad for you are being used by anti-climate change lobbyists. Not only are they using the same tactics, but they are often employing the same paid scientists to say that the science is not clear. This video brings up a good opportunity for an open discussion about how science is viewed and how the public can be easily confused when it seems like there are counterarguments on both sides of an issue. It also segues into the next video from John Oliver.[155]

One thing that gives credence to the argument that the science is not clear on an issue is that often a news program will have one person arguing that humans are causing climate change and one person arguing against this. By its nature, this gives the impression that there is a 50:50 divide on the issue of climate change. In this video from *Last Week Tonight with John Oliver*,[156] Oliver in just under 5 minutes does an admirable job of debunking this. One of the first thing that Oliver does is talk about opinion polls. He showed a clip from MSNBC, where one of the participants says a recent poll showed that 1 out of 4 Americans is skeptical of the effects of climate change and thinks the issue has been exaggerated. To which Oliver replies, "Who gives a shit?".

We do not need people's opinions on a fact, Oliver continues. You can have a poll and ask: "Which number is bigger 5 or 15?" or "Do owls exist?" or "Are there hats?". It does not matter what the polls state, a fact is a fact. He states that the debate on climate change should not be does it exist, but what should we do about it. Oliver then talks about how on TV there is always a debate with just one person arguing for and just one person arguing against humans causing climate change. He then deadpans that it is always Bill Nye arguing for the existence of human-made climate change. He ends the video stating the only way to accurately frame the debate on climate change is to have 100 people arguing with 3 of them arguing against the existence of human-made climate change and 97 arguing for the existence. This ends in chaos as expected.

A number of John Oliver segments were used in the class and were constantly the ones that draw the most laughter and created the most class discussion afterwards. His segments are very hilarious, well-researched, thought-provoking and often controversial. All of these are ingredients for an engaging tool for a lecture.

Next, a video from It's Okay to be Smart[157] is shown. This video explained why people are so reluctant to change their opinions on an issue when presented with facts. It is a great video that talks about people's psychology focusing on people's optimism bias and conformational bias and other ways that people ignore things that are too complicated or not directly affecting them now. This is a good video to wrap up the climate change talk because it is not drowning in facts and does not take one view or the other but just explains how people's brains can trick them and if they are aware of this, they can overcome these unconscious biases that we all have.

4.3 In Conclusion

In the end, was this an effective teaching methodology for this nonscience majors course? There were many goals for these courses, and the ultimate success of this course (and CHEM 1001) is determined (and will continue to be determined) by the success or failure of achieving those goals. The goals of creating these courses were to:

1. Create a fun and innovative way to communicate science to nonscience majors;
2. Improve the communication skills of nonscience majors;
3. Improve author's communications skills to nonscience majors;
4. Create a compelling nonscience majors chemistry course to compete with the offerings of biology, physics, and earth and environmental sciences;
5. Determine and address author's deficiencies in chemistry that relates to daily lives; and
6. Foster critical thinking skills and skeptical mode of thinking in nonscience majors.

The success of goals 1, 3 and 4 can be analyzed by the course evaluations[158,159] and the enrollment number of the course (summarized in Table 7), while other measures are necessary for goals 2, 5 and 6.

The evaluation of goal 1 focused on five items from the course survey:

1. The instructor's manner of communicating was easy to understand.
2. The instructor's lectures, explanations, and feedback were clearly presented.
3. I am more knowledgeable in this subject as a result of this course.
4. I would recommend this instructor to other students.
5. Overall, this instructor is effective teaching this course.

Table 12 summarizes the results from the last two semesters the course was taught, including the online cohort in spring 2017. The spring 2016 department averages for the five items were 4.73, 4.60, 4.62, 4.61, and 4.67, indicating this course outperformed all others in the department (and much of the college). Especially enlightening is the 4.95/5 on the item covering communication.

Table 12: Course Survey Results, Spring 2016–2017

Question #	*Spring 2016 (N = 36)*	*Spring 2017 (online, N = 10)*	*Spring 2017 (N = 57)*
1	4.95/5	4.70/5	4.79/5
2	4.89/5	4.80/5	4.74/5
3	4.66/5	4.80/5	4.65/5
4	4.89/5	4.80/5	4.72/5
5	4.94/5	4.80/5	4.74/5

The student comments were overwhelmingly positive. They also provided good feedback on ways to improve the class and confirmed that the video method for teaching was highly effective. Some of the specific comments from students are listed below:

- BEST CLASS IN THE WORLD FOR NON SCIENCE MAJORS. BEST CLASS EVER!!!! I loved Dr. Hickey. I was nervous about taking this class because I am not the brightest when it comes to science. Dr. Hickey made this class like Chemistry for Dummies, without the dummies part. But I thoroughly enjoyed it. It was challenging as well.
- Chemistry is something I am not strong at, but he makes the tough subject easier. He cares about everyone succeeding in his class. Professor Hickey constantly emails which shows his students that he is passionate about what he does. I wish I can have him again, I gained so much from his class.
- He is one of the most organized professors I've ever had. The examples he uses in his lectures and PowerPoint presentations are relevant and create easy connections for students to be able to retain the information. You can tell Mr. Hickey carefully crafted each of his lectures. He makes it a point to get honest feedback on the content he is teaching so that he can make improvements to his lectures wherever they may be needed, so that the student gets the most out of this course. I very much appreciate his efforts and hard work to keep us all engaged.
- His strength is his ability to bring science down to our level where we are still dealing with the important topics but in a language, we understand! He makes the subject super fun and interesting.
- His strengths are definitely lecturing skills and his passion toward the subject.
- Made chemistry fun and interesting to learn, would without a doubt take any class taught by Mr. Hickey
- Professor Hickey is the best instructor I've had during my time at UNO. He breaks down the content with great examples and visuals to help students relate and understand chemistry. I have never really been interested in chemistry until taking his course.

Goal 2 is a little more esoteric and harder to measure. Anecdotally, there seemed to be a great improvement in the communication skills of the students from their first video project to their last video project. All of the video projects from the students for all semesters of both courses are available on the course YouTube channel.[160] Students had to do metacognitive reviews of their own videos as well as other students' videos. Those comments on the videos also indicated that they saw improvement both in their own second video and in the quality of their classmates' videos. Another metric, which has not been done yet, would be to compare their essay questions on POD and tests and see how they improved from the beginning of the course.

The success of goal 3 also relied on the university course evaluations presented above, and student responses from instructor's course survey and the instructor's observations. The instructor's personal observations are that there has definitely been an improvement in teaching and communication over the four years the instructor taught these courses. Even though this is only anecdotal, the instructor feels 100% confident in saying that they are a much, much better science communicator now compared to when the courses were first proposed. In addition, the communication improvements have been seen not only in these nonscience majors classes but also in their other lectures, presentation and writing.

In terms of enrollment (goal 4), the goal was met and exceeded beyond wildest expectations. The courses are offered once per year, CHEM 1001 in the fall and CHEM 1002 in the spring. The first year, 77 students completed the course. In the last academic year, 244 students completed the courses (Table 7). In addition, a regular online section (enrollment capped at 30 students) has been offered since spring 2017. There is also a cohort of online-only degree-seeking students who use this course for their science elective (usually fewer than five per semester). Many of the advisors are pushing students toward chemistry's two-semester sequence as the course of choice for their two-semester sequence in science.

For the 5th goal, there is no doubt that in the process of creating and teaching these courses, the instructor discovered deficiencies in their knowledge, sometimes very glaring deficiencies. While these may not be in topics that relate to general chemistry or organic chemistry, they found that what they knew about topics such as nanochemistry, vaccinations, tattoos, molecular biology, genetics, medicinal chemistry, CRISPR, GMO, and many, many more topics was sadly lacking. For many of these topics, they knew they needed improvements to their knowledge base, but for others, they did not even know that they did not know enough.

One way of measuring the 6th goal is student performance on POD and test scores. Tables 9-11 show some positive results on student's critical thinking skills (especially with the VILS method of teaching). Anecdotally, students seemed to increase their skepticism (and critical thinking) when presented with facts. They no longer blindly accepted material but would think about it critically usually.

Many of the in-class POD included essay questions where students had to develop concepts, analyze multiple factors, and access higher levels of Bloom's taxonomy in order to answer the questions. In addition, about one-third of the points on the lecture tests were composed of these "thinking" questions. A number of these questions asked the students to synthesize answers from topics they had never seen before. A few examples of these questions are seen below:

- Some animals can see UV light. Some people who have cataract surgery that removes the lens covering the eye (such as the painter Claude Monet) can also see in the UV spectrum. Aphakia is a condition where the lens is missing due to either surgery (like Monet), wounds, or a congenital anomaly. Formulate a reason that people who have the lens cannot see UV light, but people without the lens can see UV light. Also, if you can see UV light by removing the lens, why do people not do it? What are the risks to removing the lens?
- Shapeshifters have been around since *The Iliad* and *Gilgamesh*. Shapeshifting can include changing into an animal, both involuntarily (werewolves or Professor Remus in *Harry Potter*) and voluntarily (Sirius Black in *Harry Potter*). It can also include mimicry (such as Mystique from the *X-Men*). Assuming a nonmagical shapeshifter/mimic exists, explain how the shapeshifting or mimicry would occur? What are the physical/biological changes in the shapeshifter's body? Be creative.
- Recall the thermite demonstration we did on the loading dock where we mixed two powders and ignited our mixture with a magnesium ribbon. An art student wants to cast (make using a mold and molten metal) a bell using molten iron. Explain how thermite could be used to cast the bell.
- Describe how oxycodone (a currently legal drug) could become the new meth. Be specific on its route from legally prescribed drug to outlawed narcotic.

A full analysis of these questions needs to be completed but there seems to be an improvement in student thinking skills as the class progressed. But this is all preliminary and there is no concrete analysis of the data yet performed to say conclusively there has been positive effects on critical thinking skills.

All in all, there is great confidence in saying that all six goals were met (and some exceeded). That does not mean that the course will not continue to evolve. Improving student communication skills and the methods to assess those skills better will continue. Additionally, the instructor will continue working on improving their teaching skills and pushing the envelope of communicating science with nonscience majors.

4.4 Future Work

The addition of the online cohort does offer some interesting possibilities for future work. As previously mentioned, analysis of online assessments is easier than traditional tests. Additionally, an analysis of online cohort versus traditional cohort might provide more subtle nuances on the effectiveness of this video communication pedagogy. In future courses, the videos for the online cohort could be given to the students to watch on their own and then answer POD and compare how that works to watching the videos live in class with discussions to follow. A full analysis of the "thinking" questions from the tests needs to be performed to compare the comprehension and retention of the material using the video intensive lecture style.

Additional analysis of performance on POD and other assessment can pinpoint which videos are working the best and which may need some tweaking. Not all lectures have a cohesive lesson plan like the climate change lesson described earlier. Some lectures jump from topic to topic as needed to cover the material. An analysis comparing students opinions and outcomes based on a cohesive, multilayered lesson plan (such as the climate change lesson plan) versus a more disjointed lesson plan should also be evaluated. Finally, a continual evaluation of each videos and how it rates for the students and how the students perform on POD needs to be carried out annually.

Chapter 5 The Round Table of Science Communication

The creation of these nonscience majors courses, along with the development of the curriculum and pedagogical approach for these courses, forced an evaluation (and reevaluation) of teaching methodology and development of new lesson plans. Amongst the discoveries was a realization that a formalized way of visualizing scientific communication could be helpful for tailoring lesson plans to the various target audiences. Upon reflection, the round table of science communication was born.

Science communication takes many forms depending upon the audience. A lecture on neurotransmitters is very different depending if the lecture is given to undergraduates, graduates, a symposia or class of middle schoolers. But, no matter to whom one is communicating, there needs to be a connection between the speaker, the audience and the topic. Every teacher learns this lesson at one point or another. Often this lesson is learned in a very hard way when a lesson plan is either way too hard or way too easy for the intended audience. Although all teacher's eventually figure this out (as has the author), most do not formalize the process or visualize it in anyway. It often takes some outside influence (such as writing a dissertation) to crystallize our thinking about scientific communication.

For the author, science communication can be analogized as a round table (Figure 17). Sitting around the table are chairs that represent all the groups to whom scientists communicate. The round table itself represents a blank slate from which can be built a compelling narrative to communicate to the target audience. The narrative is built upon strong foundational supports that represent the tenets that all science communicators must adhere to in order to be most effective. The narrative will be tailored to the audience that is being communicated to, i.e., those chairs around this science communication round table. This means that one topic can be presented five different ways depending on the audience.

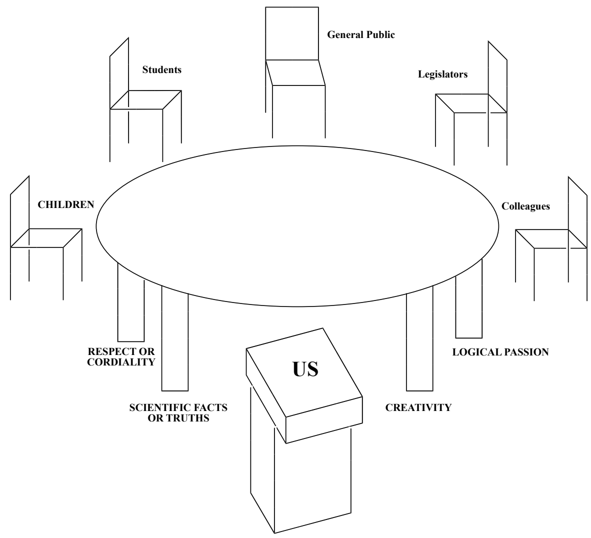


Figure 17: Representation of the "Round Table" of Science Communication. Created with ChemDraw by the author.

The chairs around the table represent children, students, general public, legislators, and colleagues while the lectern represents the scientist, the communicator (Table 13). The children represent all the youth (K-12 students, girl and boy scout troops, kids at National Chemistry Week….) that attend any outreach activity looking to have fun and be thrilled by the possibilities of science. The students represent all our students, whether they are middle school, high school, undergraduates, graduate students or even post-doctoral students. The general public is all the people that scientists communicate with via op-ed pieces, YouTube videos, Science Café events, popular literature, movies, TV or any other way that scientists communicate with the general public.

The legislators represent anyone affiliated with local, state or federal government to whom scientists advise or consult on the science that affects the laws that they will be enacting or deliberating. Legislators are also represented by the legislative staff that includes chief of staff, aids and especially scientific consultants who often function as colleagues to the scientific communicator.

Colleagues represent peers at universities, research institutes, chemical companies, pharmaceutical companies and more. The communicator is the scientist, the chemist, the professor. When scientists are lecturing, writing, recording a video, posting on social media or any other form of communication, they are communicating scientific truths to their audience and they must do so in the best possible method for that particular audience to whom they are communicating.

Table 13: Five different target audiences for science communication, the pedagogical level and example communication of each audience.

Round Table-Chairs (target audience)			
Audience	Examples of Audience	Pedagogical Level	Example Communication
Children	Outreach events Girl or boy scouts National chemistry week	Very low	Often demonstrations, Explanation is low level
Students	Middle, high school Undergraduate or Graduate students	Low to High	Lectures Active learning Notes
General Public	Concerned citizens Entertainment consumers Internet browsers	Low to Medium (Occasionally High)	Town halls, science café YouTube videos Movies or TV Op-Ed or Literature
Legislators	Legislators Legislative aides Science advisors	Low to Medium (Occasionally High)	Specific and topical Responding to questions Explanation of information
Colleagues	Faculty Research chemists	Very High	Journal articles Presentations Seminars

In general, scientific communication with legislators and colleagues is more formalized and often has stricter rules (journal formatting, for example). But when scientists talk to young children, students and the general public, they are able to talk less formally and incorporate different methods and media in that communication. They can communicate in ways that normally cannot be used when communicating with our colleagues and legislators.

Supporting the table are strong foundational supports (Table 14) that represent scientific fact/truth, creativity, logical passion and respect/cordiality. When communicating, the main supporting foundation must be scientific facts or truths. Scientists always need to couch any presentation or argument or video or lecture in the foundation of scientific facts. Scientists can use creativity to make that presentation as interesting, important, persuasive and powerful for that target audience. They must always give the presentation with forceful passion, but that passion must be logical. The passion of the presentation or argument cannot be so heated that the fundamental truth or facts are lost. Just as important, scientists must treat the audience with respect and cordiality. If scientists are talking to a group that is anti-vaccinations or anti-GMO, they cannot be condescending or dismissive. The goal is to present the facts in a creative and passionate way while still being respectful of our audience's opinion, faith, background.

Table 14: Four foundational supports of the "Round Table" of communication and the reason that each support is vital.

Foundational Supports	Reason
Scientific fact or Truths	Without the support of scientific facts, our communications efforts are doomed to fail.
Creativity	Without creativity, we run the very large risk of losing our audience and failing to communicate effectively with them.
Logical passion	Without passion we run the very real risk of losing them from the start. Why should they care if we are not passionate enough to care? But without logic, we run the risk of going off message or worse, becoming too passionate and lose our objectivity.
Respect or Cordiality	Without respect and cordiality, our communication, no matter how passionate, creative or factual, will just offend and turn off our audience.

A powerful, persuasive and creative scientific communicator can take a topic (any topic) and tailor it to a particular audience to get the most impact on that audience. So, as the scientist stands (metaphorically) at the lectern and deliver their "lecture" (whatever the format), they must always remember the audience (chair) to whom they are communicating. Scientists can provide the most compelling, fact-filled, perfect message ever and still not reach their audience if they forget who that audience is in the first place. The communication method for a classroom of 20 graduate students is not the same method that would be used to reach a class of middle schoolers or a roomful of legislative aides. This is not an earth-shattering revelation; it is common sense. But that "lecturer" inside of most scientists (and probably most faculty) is telling them that they learned by listening to someone at the front of the room lecture to them, so that is how they should "teach".

Traditional lecture style was the most common method used by the author prior to teaching the nonscience major courses. The instructor was very familiar with active learning and different pedagogical approaches to teaching and used these in their lecture. But it was not till they were confronted with teaching a nonscience major chemistry course did they truly begin to understand the importance of properly communicating to their audience, especially when that audience was not the typical pre-professional science major. This awareness led to the creation of the video intensive lecture style that is used in CHEM 1001 and 1002. Although this method cannot be used exhaustively in a traditional organic class, the VILS method can be used in certain lessons or lectures and could be a very useful way in teaching topics that are very challenging to students. The VILS method could also be useful in flipped classrooms.

Chapter 6 Video Intensive Lecture Style (VILS)

6.1 Introduction

Just as the reflection on communication methodology led to the formalization of scientific communication via the "Round Table", a reflection on pedagogy utilized in CHEM 1001 and 1002 led to the realization that a new teaching style had been created (or at least an old teaching style had been revamped), which was dubbed VILS (Video Intensive Lecture Style). As mentioned in the introduction,[33,35-40] the usages of videos to augment or supplement lectures is well-established in many disciplines including chemistry. However, a lecture style where over 50% of the time is devoted to watching videos during formal lecture time has not been previously reported.

Furthermore, most professors would consider this style counterintuitive, lazy and perhaps fraudulent. Why should students come to a lecture to watch videos when they could do that on their own time? Why use a video when a lecture would do the same thing? Can't you teach this on your own, why use someone else's work? These and other arguments are completely valid points of inquiry that need to be addressed and investigated.

But the simplest answer is that VILS works. As seen in 3.4 (Table 9), 3.5 (Table 10), 4.1 (Table 11) and 4.4, when comparing a traditional lecture format to VILS, VILS outperforms the traditional lecture over and over. The question to ask is why does it work? Is it sustainable? Can it be recreated? Does it only work for certain classes and with certain faculty? These are the questions that will determine if VILS works for these classes only or is a viable alternate lecture style for other courses and for different types of faculty.

6.2 Why Use Videos in Lecture?

One of the first questions many faculty would ask is "Why should students come to a lecture to watch videos when they could do that on their own time?" There are multiple answers to this. The first and foremost is that if you assign 15 videos to be watched prior to a lecture, how many students will watch all 15. Could you get 50% of students to watch all 15, maybe only 25%? If they watched them, would they be 100% focused on the videos? Even if they all watched them and were 100% focused, what percentage of the material would be retained when they came to the lecture to discuss those videos?

Second, while the baby boomer generation and some millennials are not digital and video natives, the newest cohort of students (Generation Z)[71,72] are digital natives whose first solution to most questions posed to them is to go find a video on that subject to figure out the answers. Therefore, videos are the preferred method of "data input" for the majority of our students as opposed to reading a textbook or via a traditional lecture, which were the preferred method for previous generations of students.

Third, while a student could watch a video on their own and then come to lecture to get more information on the video and answer the POD, the immediacy of watching the video and receiving additional, important and explanatory information immediately after from the faculty provides a much better opportunity for better learning outcomes for the student. Coupling the immediacy of the information from the faculty with the group dynamic of watching videos with their classmates, makes watching videos in the lecture a shared, communal experience more similar to a "social media" like experience, which the students are accustomed and prefer.

Multiple times during the lecture, students would comment during or after the videos and provide information that would not have been available to someone watching the video alone.

Fourth, the videos are curated by the faculty to deliver the biggest impact on the students. The videos are professionally done, most with a great sense of humor and well-thought out pedagogy. Often, the videos can deliver in a 3-5 minute video what would take 10-20 minutes of lecture time. While it may seem counterintuitive, the use of videos often saves time in the lecture allowing for more material to be covered.

Finally (as seen in tables 9-11), for multiple cases, the use of videos has proven more effective as a teaching methodology when compared to traditional lecturing. The evidence is still preliminary, and more analysis and work need to be done; but, initial results are very promising and indicate that this methodology works with various concepts and across all Bloom's taxonomy levels.

6.3 What is VILS and How Does it Work?

VILS is described in great depth in chapters 3 and 4 of this dissertation and also in two chapters written by the author for an\ ACS symposium series.[35,36] But, the basics of VILS is that in a standard lecture (75 minute, 2 times a week lecture), around 50% of the lecture time is spent watching videos. The videos will either be proceeded or followed with additional information and/or explanations. The videos are coordinated into an over-arching lesson plan where one video will build upon another (Section 3.3). Videos can run from 20 seconds long to 20 minutes long but usually are around 3-5 minutes in length. Longer videos will often be paused after 5-8 minutes and discussed before continuing on with the videos.

Problems of the Day (POD) act both as concept checks and higher level thinking questions and are asked between and after videos. POD can be written "quizzes" or clicker questions or surveys depending on the context of the lesson plan. Each lecture usually covers one or two topics. The lecture is designed to flow from one video to another video but still relate to the same lesson plan. As seen in section 3.3 of this dissertation, a topic like medicinal chemistry from *Game of Thrones*, can utilize videos from *Game of Thrones*, *the Rock*, *Harry Potter*, and multiple educational YouTube channels.

The goal of the VILS methodology is to create a communal feel to the lecture. Students watch videos together, comment and discuss the videos with the instructor. POD and discussions are designed to elicit higher levels of analysis and evaluation (per Bloom's Taxonomy). Cohesive lesson plans are essential. Earlier versions of the course would often bounce from one video to another without a structured lesson plan (other than similarity of topics). As the course matured, structured lesson plans were developed for more and more lectures and feedback from student (and instructor) reinforced the need for these structured lesson plans.

6.4 Application of VILS to Other Courses

VILS has not been employed in any other course but CHEM 1001 and 1002. Therefore, application to other courses is totally theoretical at this time. However, there is research available on using videos OUTSIDE of lecture in a multitude of courses. This is what is known as Just-In-Time Teaching (JITT)[33] or Flipped[37] classrooms. In JITT or flipped classrooms, the model of teaching is "flipped". A traditional lecture devotes the entire (or most) of the lecture to the teacher-centered practice of lecturing, i.e., instructor writes notes on board or talks from

PowerPoint while students take notes from the instructor. The student then does homework and practice problems outside of lecture. In a flipped classroom, the student watches videos of lectures, takes notes, and does the "traditional" lecture on their time outside of class and the classroom is devoted to working example problems, problem solving and other student-centered activities.

VILS combines aspects of both traditional and flipped classrooms. Students watch videos in lecture, discuss videos and then assess knowledge via POD or other assessment tools. This works easily in a course like CHEM 1001 or CHEM 1002 where media plays a vital role in the course. But how would it work in a course such as organic chemistry? VILS would have to be selectively used for only certain lectures that lend themselves to this methodology and the lesson plan would have to be very structured.

For example, using VILS for a second lecture on stereochemistry in organic chemistry could proceed as follows. Students would be required to read the chapter on stereochemistry before coming to class and take a pre-lecture quiz. This is the standard assignment for all chapters of organic chemistry at UNO taught by this instructor. Assume the first lecture covered the basics of stereochemistry and the second lecture was focused on identifying and classifying chirality centers and naming compounds using *R* and *S* (Cahn-Ingold-Prelog, CIP) rules.

A VILS lecture would start with a quiz to set baseline knowledge of students prior to lecture. This would be followed with a short, overview of CIP rules and assigning chirality centers. Next, a video would be shown on how to determine *R* and *S* by just visualizing the molecule in 3-dimensional space. A short discussion would follow and then a worked example or two would be done. Then, a video would be shown using molecular model kits to determine

R and *S*. Again, a short discussion and worked examples would follow. Finally, a video could be shown using "tricks" to solve *R* and *S*, such as if the smallest group is wedged, then assign *R* and *S* and reverse the answer. If the smallest group is neither wedged or dashed, then do the double switch and then assign *R* and *S*.

After these videos, students can be assigned 3 problems and they have to solve each problem using a different method. After solving those problems, students can be asked which way they prefer to solve the problem. A short recap discussion will follow and then a post-lesson quiz will be administered. Students will be given 5-7 problems. Three of the problems must be done with an assigned specific method (visualization, model kits or tricks) and the other problems can be done using any methodology. After the quiz (or at the beginning of the next lecture), there would be a discussion of the methodology utilized for each problem and what worked best for the students.

Analysis could be done for the VILS methodology of teaching stereochemistry versus a traditional lecture on how to classify chirality centers. Pre and post lecture quizzes would be the best metric of this analysis (along with analysis of test and exam scores). But, student evaluations of how effective each method was for their understanding of stereochemistry would also be a very important metric in the analysis of these two methodologies.

Depending upon the effectiveness of VILS, this methodology could be applied to other topics that would be amiable to the VILS methodology. For example, intermolecular forces, spectroscopy, S_N1 vs S_N2, Diels-Alder, Claisen rearrangements, Aldol reactions could all be taught using VILS methodology. Topics in general chemistry could also be analyzed to figure out which would be most likely to work well with VILS methodology.

6.5 Future Work

The online cohort of CHEM 1001 and 1002 will be a great source for this data. An analysis of how many of those students click and watch the videos that are assigned can be done. While this will not provide scalability to all populations, it will give an initial view of how many of these videos are watched. Additional questions can be posed to see if students in the online cohort retain the material. A comparison on POD and thinking question performance for the lecture cohort versus the online cohort could provide information on retention of the material from viewing material prior to a “lecture” versus during lecture. Additionally, a study can be conducted where some lectures ask the students to watch the video prior to coming to lecture and compare their performance on POD versus the cohort who watched the videos in lectures. A simple way of checking student’s preference for learning can be done using Qualtrics or some other survey method.

As mentioned in section 6.4, a comparison of pre and post lecture quizzes in a traditional lecture versus a VILS lecture in organic chemistry or general chemistry could assess the scalability of VILS to other classes. Additionally, VILS will need to be tested at other institutes of higher learning (community colleges, private universities, large PhD granting universities, liberal arts colleges, HBCU…). Also, different faculty would need to test this to make sure there is not a faculty bias in VILS.

VILS was not the result of a well-thought out research study. VILS developed on its own, “organically” from teaching CHEM 1001/1002. The concept of using videos to help teach the course was a conscious decision but the percentage of time in lecture spent watching videos and the reaction to this teaching method from the students led to the actual formalization of this lecture style. As such, there was not a designed plan to analyze VILS, nor was there even an acronym VILS or the idea of creating a new teaching style until analysis of the first year teaching the course illuminated that a new teaching style may have been created and may potentially be a very useful method of lecturing to generation Z students.

Chapter 7 Pedagogical Changes in Organic Chemistry Lecture

7.1 Introduction

The author has taught organic lecture at the University of New Orleans for almost 15 years. During that time, multiple changes have been made to improve student outcomes in the lecture. The first change was the addition of recitations in 2003. Online homework was introduced in 2005 and has been adapted as the homework systems changed. Video recording of lectures started around 2007. Clicker questions and other active learning techniques were added starting around 2011. Active learning included problem-based learning,[34] peer instruction,[26] group work and conceptual quizzes. Sections 7.2-7.5 discusses the implementation of each of those changes. Section 7.6 discusses the evolution of the lecture to be a complement to the student study cycle and modern, online, interactive textbooks. Section 7.7 discusses the effects of these changes on students outcomes and perceptions.

7.2 Implementation of Recitations

Recitations were added to the organic chemistry lectures in 2003. The implementation, analysis and future work involved in those recitations has already been discussed in sections 1.1-1.3. Of note, organic recitations were implemented prior to general chemistry recitations at UNO. Recitations were implemented initially on a trial basis as voluntary recitations. Immediately, it was noted that the recitations were helpful but were poorly attended and usually the better students attended instead of the students who needed help. Formal implementation of recitations through courses and curriculum committee was based on the recitations being mandatory. Recitations have had mixed results in organic chemistry according to the author's students while instructors have felt they are a very positive addition to the course.

7.3 Implementation of Online Homework in the Organic Lecture

In 2005, online homework was added to the organic lecture using eGrade PLUS from Wiley Publishing. This system was integrated with the lecture textbook, *Organic Chemistry* by Solomons.[161] The initial usage of online homework was fairly rudimentary with most questions being multiple choice, which assessed for core conceptual knowledge but did not test higher levels of Bloom's Taxonomy. Over the years, publishers have invested money and resources and the online homework systems have greatly improved, especially with the addition of drawing questions, predictive analytics and adaptive learning.

Around 2007, Wiley upgraded their online homework to include drawing questions that were initially powered by MolQuiz, an open resource software but are currently powered by ChemAxon's MarvinSketchJS.[162] Additionally, 2007 saw the introduction of mastery assignments to WileyPLUS and the organic course. Around 2010, a new arrow pushing, mechanism program created at UC-Irvine was introduced to WileyPLUS.[163] This system allows students to practice reactions, mechanisms and synthesis using a proprietary program that can auto-generate and auto-grade problems.[164-166] In 2015, an adaptive practice module titled ORION was added to WileyPLUS and incorporated in the lecture.[167]

The introduction of drawing questions into the online homework allowed for students to draw organic molecules (including stereochemistry), products of reactions, complete mechanisms, Lewis structures and most other drawing that previously had been only available via handwritten homework. For the instructors, the benefits were numerous and included having a huge database of questions to pick from for homework assignments, time-saving via auto-graded questions and the ability to cut down on cheating via algorithmic or pooled questions. For students the advantages included instantaneous feedback on their mistakes, the ability to attempt the problem multiple times, large pools of practice problems and the ability to review all work.

With the addition of drawing questions, also came a new type of problem set called mastery homework. A separate database of over 25,000 questions was introduced in the mastery homework. Around half of these questions were multiple choice and the other half were drawing questions. The questions were segregated by topic. For example, sets of questions were titled E2 reactions, S_N2 reactions, Diels-Adler reactions and so forth. These questions sets were pooled together usually in sets of 100-400 questions. There were 4-15 mastery assignments per chapter.

Once assigned, students would access the assignment and every student would get a random set of 10 questions that was unique to each student. The default assignment awarded 10/10 points if a student got 8, 9 or 10 questions correct; 5/10 if a student got 5, 6 or 7 questions correct; and 0/10 if a student got less than 5 questions correct. Students are allowed only one attempt per question but after each attempt, the correct answer and feedback along with explanation is given to the student. Students can reset and attempt the assignment as many times as they need to get their desired score.

For the instructors, these assignments provide multiple benefits. Students will often take 3-5 iterations through the assignment before mastering the material. In that process, they are doing what instructors want students to do, which is practice, practice, practice.

Additionally, students report that they pay specific attention to the correct answer and the feedback to minimize the number of iterations of the assignment they must do to gain a perfect mastery score. Mastery assignments force students to practice multiple examples of a problem, paying specific attention to what they got wrong. Students will attempt the set over and over until they master the topic. This is the desired study cycle that is needed for success in organic chemistry.

For students, the desire to get a 10/10 on the assignment is a great motivating factor for them to try the problems over and over during which they get the requisite practice to master the material. The mastery assignments are invariably the highest rated assignment in WileyPLUS because the students feel that the ability to try again and again is the fairest method for online homework. Additionally, many students have reported that they have figured out a "trick" or "cheat" to the problems as they went through them. For example, a student reported once that they figured out a trick that substitutions cannot be done when the halogen is attached to a double bond. In lecture, the student obviously did not understand that limitation of substitution reactions but figured it out due to practicing the mastery assignments multiple times.

The incorporation of reaction explorer in 2010 represented another big step forward in the evolution of online homework. Reaction explorer consisted of three independent programs: reaction drills, mechanism explorer and synthesis explorer. Reaction drills consisted of over 100,000 flashcards that had either the reactant, reagent, product or one of the three at random missing. Students could click on the missing part of the reaction to reveal the correct answer like a standard flash card. The advantages are that the flashcards are premade, with different parts missing and can be accessed anytime via computer, phone or tablet. The reaction drills flashcards were grouped by reaction type (E1, E2…) and also by chapter (all chapter 8 reactions…). Reaction drills were for practice only and were not a graded assignment.

Mechanism explorer used a predictive engine to test student's ability to push electrons with arrows. Mechanism explorer could be used both for practice and for graded assignments. Synthesis explorer also used a predictive engine to test student's ability to string together a series of reactions to produce a target molecule. Synthesis explorer also could be used both for practice and for graded assignments.

Prior to 2010, mechanism questions were only done either by multiple-choice, matching questions or via standard drawing questions. The issue with the standard drawing question was that students had to enter the entire reaction and arrows and the slightest mistake would make the entire question wrong without indicating why it was wrong. Often an answer would be chemically correct but not match the expected answer and this proved very frustrating for student and instructor. For example, a student could have abbreviated a methoxy as OMe instead of drawing it out as O-CH_3. The system would grade it wrong even though it was correct.

In mechanism explorer, students will be given the reaction for the mechanism to solve and the reactants/reagents of the first step of the mechanism will be populated for the students to solve (Figure 18). Students will need to draw the arrow(s) that will generate the product of the first step of the reaction. The computer program will auto-generate the product that results from the arrows drawn by the student. If that product matches the expected product of the mechanistic step, the program will populate the next step of the mechanism for the students to complete and so on until the mechanism is complete. If that product does not match the structure of the product of the mechanistic step, the original reactants/reagents will repopulate for the student to attempt again. The incorrect product that the student's arrows generated will be shown so the student can see the consequences of their arrows (Figure 19). The system only allows arrows to originate at a lone pair or a bond and can only terminate at an atom, eliminating potential errors for not placing arrows exactly 100% correct. The system will not allow them to place the arrow on the wrong type of electron density.

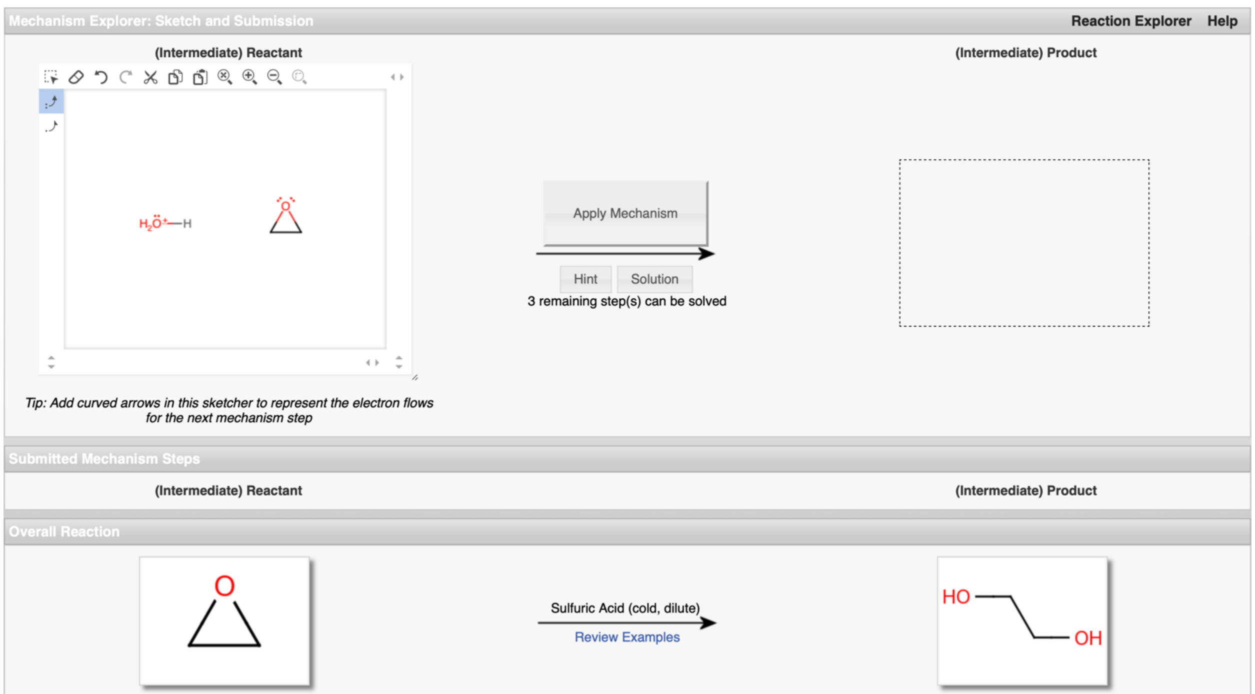


Figure 18: Example of a Mechanism Explorer from WileyPLUS course of Klein, Organic Chemistry, Wiley. Reproduced with permission from Wiley Publishing.

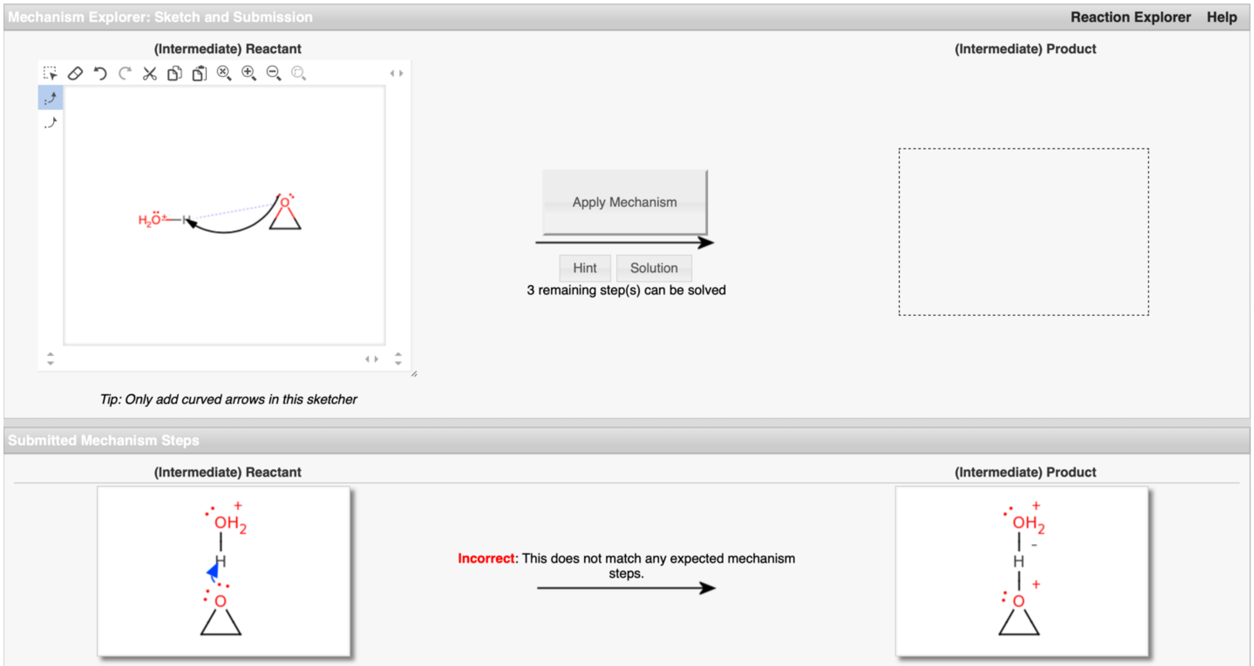


Figure 19: Example of Wrong Answer Feedback from a Mechanism Explorer Question from WileyPLUS course of Klein, Organic Chemistry, Wiley. Reproduced with permission from Wiley Publishing.

For instructors, these assignments test the student's actual knowledge of electron pushing arrows, not their technological skills. Additionally, the assignments are pools of mechanisms (i.e., the instructor assigns S_N2 mechanism pool not an individual mechanism question) where each student gets their own question from the pool and lessens the likelihood of cheating. Students are not penalized for the number of attempts to solve the problem. Students get instantaneous feedback on incorrect mechanistic steps and can learn from those mistakes.

In synthesis explorer, students are given a target molecule that they need to synthesize. They are given a series of reactants and reagents that they can use to make that target molecule. Students select a reactant(s)/reagent combination and the system auto-generates the product of that reaction. The student then selects that product to continue on with the synthesis until product of their reaction matches the target molecule (Figure 20). Students are not given feedback after each step other than the product from their proposed reaction step. Like mechanism explorer, target molecules are randomly generated to prevent cheating. Any pathway that gets to the target molecule is accepted, allowing for greater flexibility in grading. Synthesis explorer also allows for free exploration where students can pick any combination of reactant and reagent to see what would be generated from the combination.

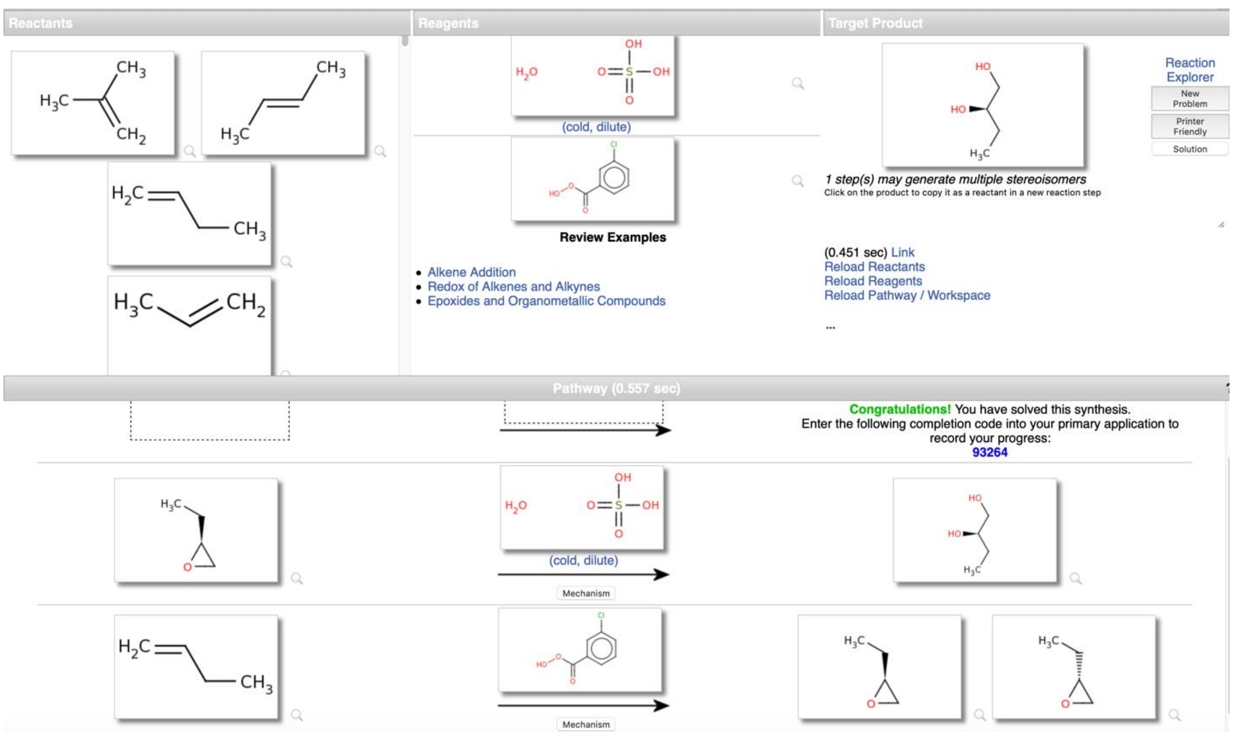


Figure 20: Example of a Synthesis Explorer Question from WileyPLUS course of Klein, Organic Chemistry, Wiley. Reproduced with permission from Wiley Publishing.

ORION is the adaptive tool added to WileyPLUS in 2015. In this assignment, students take a static quiz (all students get the same questions) to set a baseline of understanding for the chapter. Based on various factors (correctness, time on task, difficulty of question, student confidence), the students are assigned an initial proficiency that is calculated both on a chapter level and a section level. At this point, the students have complete control of their learning. They can opt to practice either on a section or chapter level. The questions they get will be adaptively selected based on their current proficiency in the section/chapter. If students are highly proficient in a section, they will get very hard questions. If they are not proficient, they will get easy questions until they raise their proficiency.

ORION gives the students four different type of reports to use: metacognitive, most challenging activity, performance and productivity. The performance report allows students to check their proficiency section by section or chapter by chapter. It also allows students to see all of their questions they have attempted. The productivity report shows the student's performance versus time on task. The metacognitive report shows the student's performance versus confidence. The most challenging activity report ranks all sections/chapters of the course the student has attempted from worst performing to best performing. All of these reports allow students to determine what they know and what they do not know and tailor their studying to make the most efficient usage of their time (Figure 21).

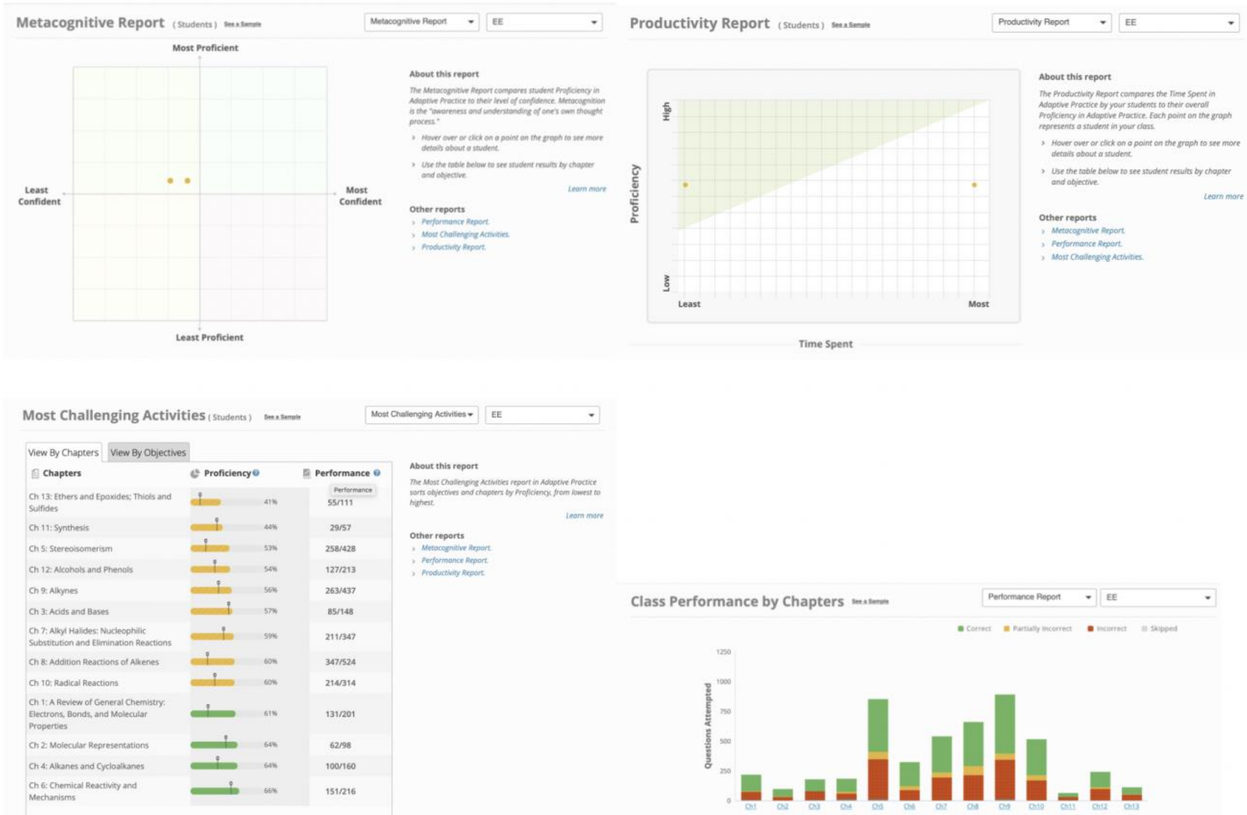


Figure 21: ORION reports from WileyPLUS course of Klein, Organic Chemistry, Wiley. Reproduced with permission from Wiley Publishing.

7.4 Implementation of Video Recording in the Organic Lecture

Around 2007 video recording of the lecture was added to the organic class. The video recording was done using a screen capture tool that captured both the audio of the professor and video of the PDF presented in class with all the markups. Initially, the screen capture was done using software from Shinywhitebox.[168] Videos were uploaded to the Learning Management System (LMS) initially and later to iTunes U.[169-171] Due to some instability with the

Shinywhitebox software, the screen capture tool was switched to a program from Telestream called screenflow.[172]

The recording of the lecture took almost no effort by the faculty but paid huge amounts of dividends for both faculty and students. First, students were encouraged to watch previous semester's videos before coming to lecture to be better prepared for the class (similar to Just In Time Teaching or Flipped classrooms). Students were also encouraged to watch the current semester's video (or previous semester's videos) to review and reinforce material that they missed or did not understand fully during lecture. Students were told to make notes of topics and/or times during the lecture that they would need to review and watch the appropriate sections of the video.

Furthermore, students who had to miss lecture could watch the video and not fall behind. Videos provided a curated, correct source for students to watch and prepare for the test as opposed to going online and finding a video that could be focused on something slightly different or taught using a different methodology, or cover something not covered in class, or not cover a topic covered in class, or that was just completely wrong.

The main disadvantage to the recording of the lecture, is that students could think that coming to lecture was not necessary because they could always watch the video. The students were told that watching the video at home was no substitute for coming to lecture; however, there was a drop in the overall attendance after video recording of lectures was implemented. This problem was alleviated by the addition of active learning exercises such as quizzes that were implemented in the lecture starting in 2011.

7.5 Implementation of Active Learning in the Organic Lecture

Active learning was fully introduced sometime around 2011 into the organic lecture. Prior to 2011, there had been some in-class activities, such as quizzes, group work, that would have been considered active learning. But these were not constant and their effects on student outcomes were not measured specifically. In 2011, in-class quizzes were formalized with the integration of iClicker response systems into the class. The iClicker response system was also used for group work. Students would be given a problem to work in groups at their desk and then each student would individually enter their group answer into the iClicker response system.

Often faculty pick one active learning methodology and use only that methodology in the classroom. For example, they will use only clicker quizzes or only PLTL[24] or POGIL[25] or peer instruction[26] and so forth. The reasoning is twofold. First, they are usually familiar and comfortable with that one methodology. Second, if they are conducting chemical education research, they only use one methodology so that they can measure the effectiveness of that one system compared to a control. At UNO, various methodologies were used in the lecture. It was determined that different methods worked better based on the complexity of the question and the desired outcome.

In general, a classroom response system (iClicker and TopHat were used at UNO) was utilized to collect the data. The problems used in class were taken from a variety of sources that included textbook ancillary material, online homework problems from textbook or clicker system and instructor-created questions. The main active learning methods used were concept quizzes, Problem-Based Learning (PBL)[34] and peer instruction. The complexity of the problem and the desired outcome of the assessment dictated the choice of active learning methodology.

The clicker quizzes usually were generated from textbook ancillary material (pre-created clicker quizzes). The group problem solving sessions usually utilized questions from online homework or were instructor-created. The peer instruction sessions almost always utilized questions that were instructor created. The amount and usage of active learning in the lecture changed and matured over the years from a simple clicker quiz (2011) to multiple levels and types of assessment (2015). A typical lecture (Diels-Alder Reaction) with active learning is described below:

- Class would often start with a simple concept clicker quiz to assess student's retention of previous material (Figure 22).
- A traditional lecture (with worked examples) would be given using a PDF of the chapter (and notes) that would be marked up and projected to the students (Figure 23)
- Students would then be given either a conceptual quiz or be asked to work problems individually (Figure 24)
- Solutions and explanations of the problem would be given followed by more complex examples of topic (Figure 25)
- Students would then be given more complex problems to be worked in groups (Figure 26)
- Peer instruction would sometimes be used with harder examples (Figure 27)

Peer instruction involves students working on a very complex problem independently to get an answer. After the students have spent time working on the problem individually, the students will gather in small groups to discuss their individual answers. Students will discuss all the answers and determine which they think is correct amongst their answers or maybe they will come to the conclusion that they all had it wrong and come up with a new answer. After this discussion, the students in each group will turn in their problem with the answer they think is correct following the group discussion. Most groups will come to a consensus answer. But it is not uncommon for some group members to champion one answer and other groups members to champion another answer. Once the students turn in their final answer, the instructor will go over the solution and explanation to the problem. Research has shown that on complex problems, peer instruction works better than individual or group problem-solving. The caveat is that the problem must be one that at least half the students get wrong initially. If the problem is too easy, the effectiveness of peer instruction decreases. This is why peer instruction is reserved for only complex questions.

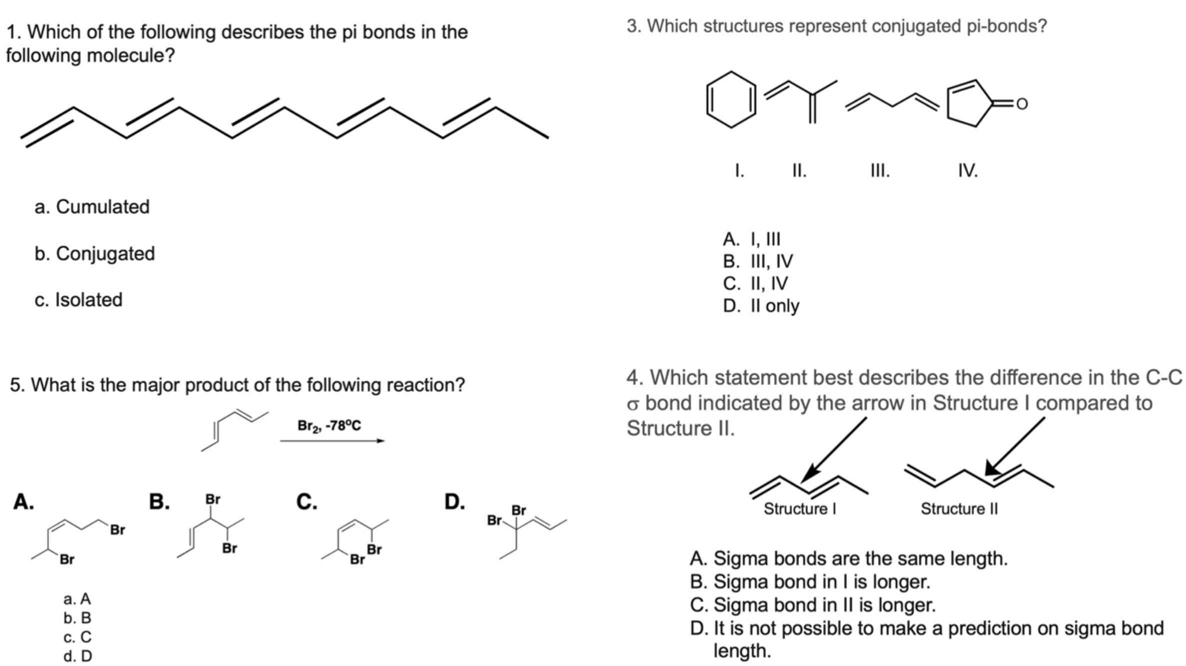


Figure 22: Example of Clicker Quiz Used in Diels-Alder Lecture (Klein, Organic Chemistry, Wiley). Reproduced with permission from Wiley Publishing.

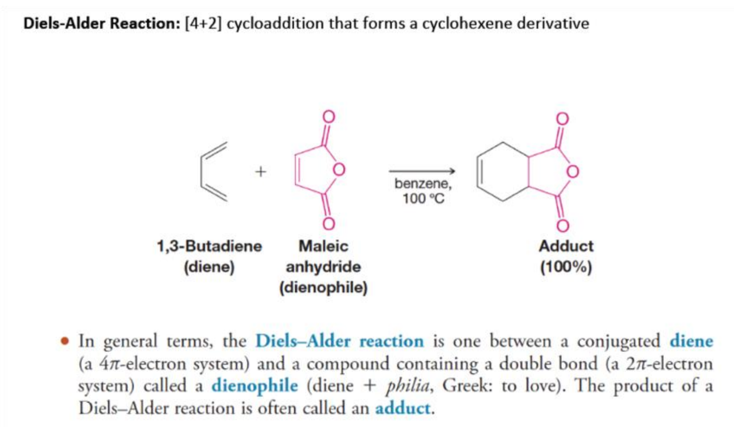


Figure 23: Diels-Alder Reaction from Klein, Organic Chemistry, Wiley. Reproduced with permission from Wiley Publishing.

TRY IT ON YOUR OWN:

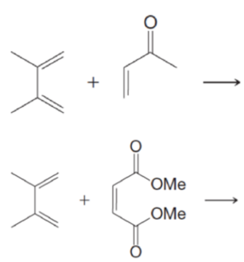


Figure 24: Example of Problem Set Following Introduction to Diels-Alder Lecture

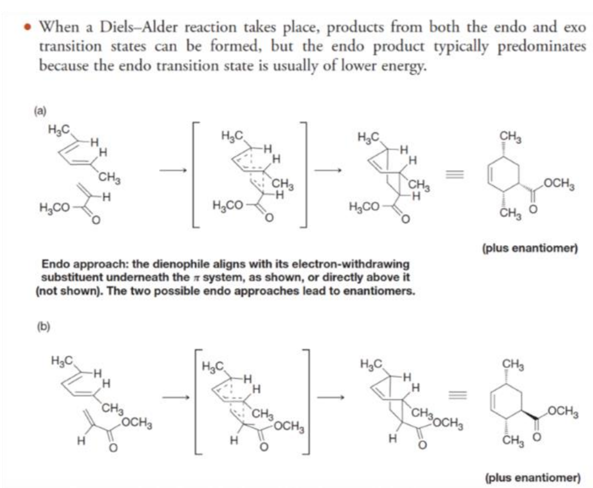


Figure 25: Endo Rule for Diels-Alder Reaction from Klein, Organic Chemistry, Wiley. Reproduced with permission from Wiley Publishing.

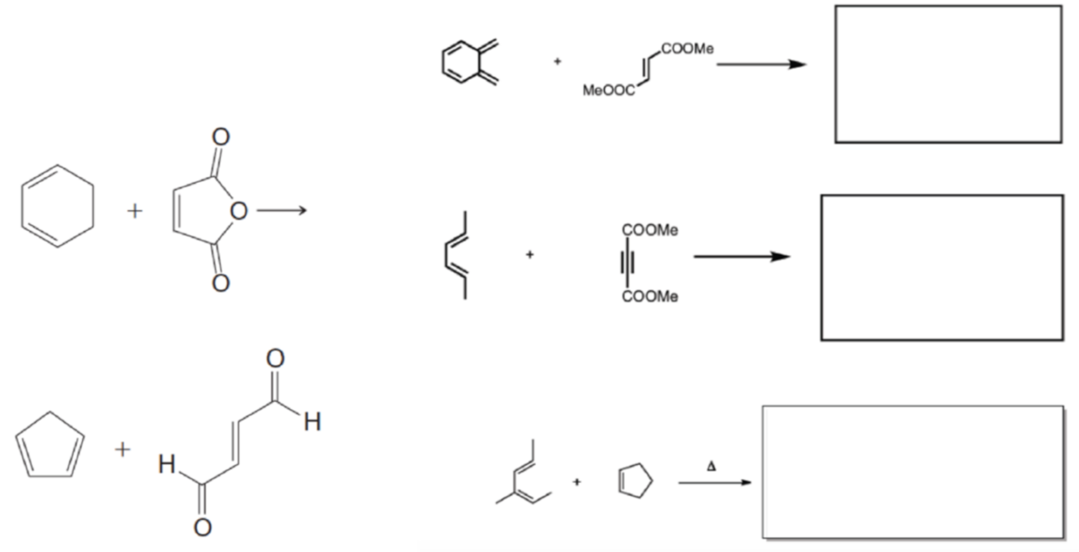


Figure 26: Example of Group Problem Set

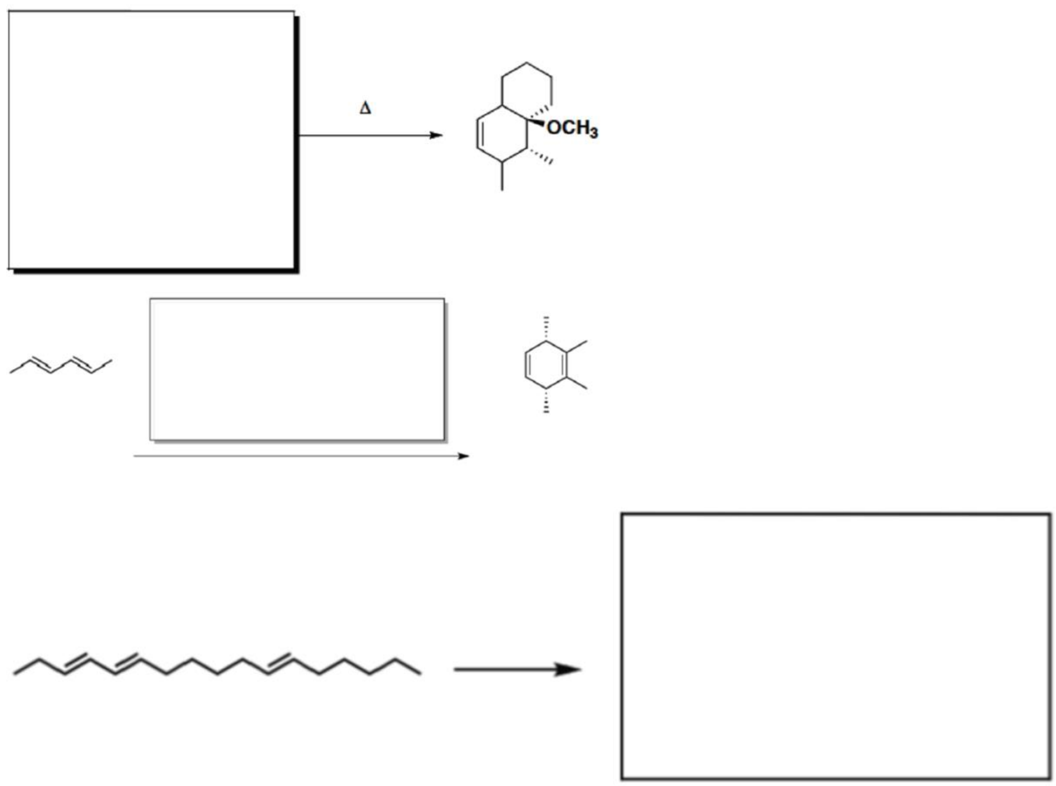


Figure 27: Example of Peer Instruction Problem Set

7.6 The Study Cycle and Creation of Interactive, Textbook for Wiley Publishing

As described in section 7.6, a typical organic lecture would start with a short clicker quiz to ensure students understood the concepts from the previous lecture. Next, there would be a traditional lecture followed by clarification of concepts using various methodologies and analogies. Often, a clicker quiz would follow to test student understanding of the new concepts. Worked problems would follow the clicker quiz. Finally, an opportunity for students to work problems either on their own or in groups with either a standard quiz or through a peer instruction model would wrap up the lecture. In addition to the problems done during lecture, students take a pre- lecture quiz online to prepare them for the upcoming material. In this overall process students do the following:

1) **Preview** new material (pre-lecture quiz)
2) Review previous material (clicker quiz)
3) **Attend** lecture and take notes (traditional lecture)
4) **Review** material (conceptual quiz or group work)
5) **Study** new material by using harder examples (traditional lecture and examples)
6) **Check** their understanding (harder peer instruction problems

The scaffolding[133,134] approach utilized in the interactive lecture very much mimics how modern, interactive textbooks work (Figures 28-31). Both the lecture and the textbook use an interactive methodology designed to accomplish an ideal student study cycle.[173-175] LSU's academic success center introduced the concept of the study cycle to show students how to improve their study skills. The study cycle starts with a **preview** of material prior to attending lecture, followed by actually **attending** lecture and participating in the lecture, followed by a **review** of lecture material, then **studying** of material and final a **check** to make sure the material is understood prior to the next lecture.

The organic chemistry lecture has evolved (both by design and serendipitously) to meet the needs of the students of today. Students were given a guided pathway through the lecture that mimics the ideal study cycle. Students were also given multiple ways of visualizing the concepts and the opportunity to work through those concepts using an interactive, active learning environment that is built to foster the best learning environment for the students. The interactive classroom environment was reinforced by the interactivity of the modern textbooks. Students were made aware that their best chance of success was to use both the lecture and the online textbook. These two resources reinforce and complement each other and provide the best option for success.

The first step in the study cycle is to **preview** the material, which is accomplished with a pre-lecture quiz (clicker quiz) in the lecture. The interactive textbook starts with a Do You Remember section (Figure 28) that includes a quiz that students can take to make sure they have the requisite knowledge for this chapter.

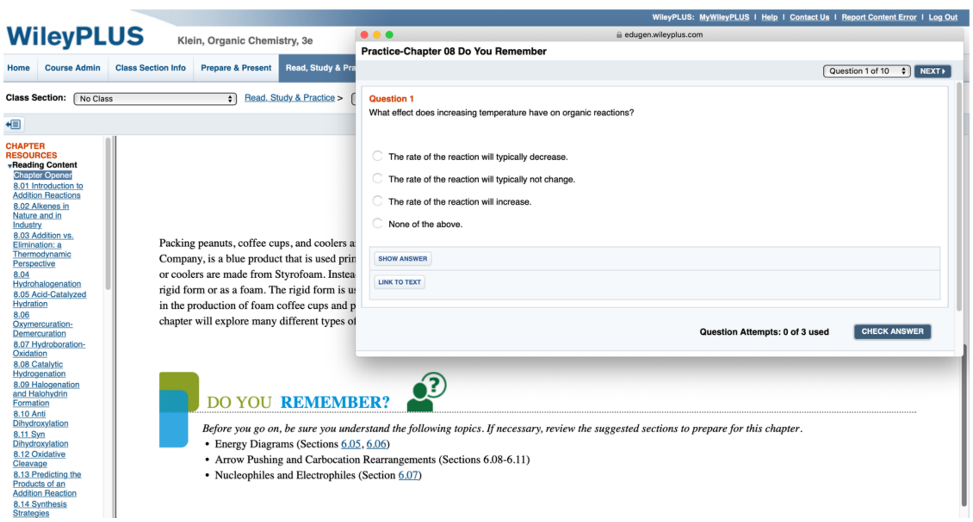


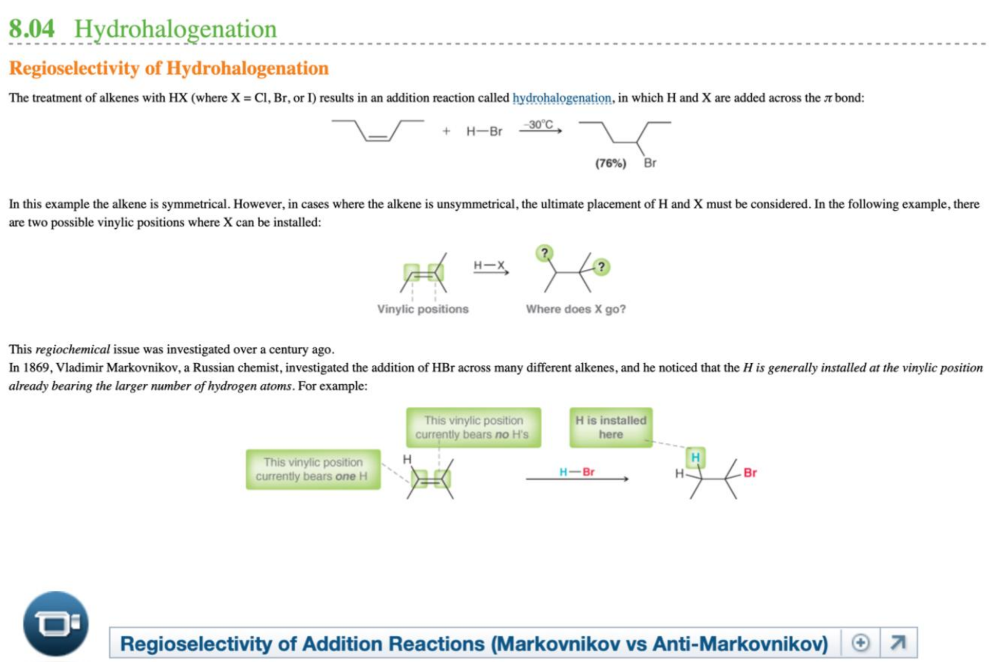
Figure 28: Do You Remember Quiz from Chapter 8 of the online WileyPLUS course of Klein, Organic Chemistry, Wiley. Reproduced with permission from Wiley Publishing.

Without realizing it, the evolution of the lecture from a traditional lecture to an interactive lecture was the catalyst for the design of two interactive textbooks for organic chemistry at Wiley Publishing. The author designed the online, interactive textbooks for Solomons, *Organic Chemistry*[161] and Klein, *Organic Chemistry*[176] while employed at Wiley Publishing. The designs of those textbooks, which have been widely been praised, mimics the lecture style developed at the University of New Orleans.

In the organic lecture for the addition to alkene reactions, the theory of regioselectivity would be introduced with a traditional lecture style (similar to the traditional exposition of a textbook) and then examples, anecdotes and other methods of pedagogy would be used to explain the topic so that students could understand (similar to the embedded videos in the textbook). While the video in the interactive textbook might focus on showing a 3-D visualization of the changes in the alkene or go through more examples and theory, the lecture will often try and analogize the reaction to something the students can understand and have seen in their day to day lives.

For example, regioselectivity could be explained (in the lecture) using the example of two people carrying a heavy object (similar to two carbons connected by a double bond). One person needs to let go of the object to open the door or pick up something (just as one of the carbons pick up the hydrogen in an HBr addition to alkene). A decision has to be made on which person holds the entire weight of the object and which person lets go and picks up the object/opens the door. The person better equipped to hold that weight will volunteer to hold all the weight. Similarly, in an alkene, the more substituted carbon is better equipped to hold the positive charge, so that is where the positive charge will go preferentially while the other carbon picks up the hydrogen.

Figure 29 shows a section of Chapter 8 from Klein, *Organic Chemistry*. In section 8.4, students are introduced to a topic (regioselectivity) using traditional textbook pedagogy, exposition and drawn structures. After introducing the topic, a video is available in the online textbook to explain the topic using a different media to help the students understand the topic in a different light or for students who learn better from video than reading. As mentioned above, this scaffolding structure is also used in the lecture. The lecture would start with theory and background on addition to alkene reactions and then go into the anecdote mentioned above.


8.04 Hydrohalogenation

Regioselectivity of Hydrohalogenation

The treatment of alkenes with HX (where X = Cl, Br, or I) results in an addition reaction called hydrohalogenation, in which H and X are added across the π bond:

In this example the alkene is symmetrical. However, in cases where the alkene is unsymmetrical, the ultimate placement of H and X must be considered. In the following example, there are two possible vinylic positions where X can be installed:

This *regiochemical* issue was investigated over a century ago.

In 1869, Vladimir Markovnikov, a Russian chemist, investigated the addition of HBr across many different alkenes, and he noticed that the *H is generally installed at the vinylic position already bearing the larger number of hydrogen atoms*. For example:

Figure 29: Explanation of Regioselectivity from Section 8.04 of the online WileyPLUS course of Klein, Organic Chemistry, Wiley. Reproduced with permission from Wiley Publishing.

After the introduction of the topic in lecture, a concept quiz would be given. This would often be a clicker quiz just to make sure students understand the basics before moving to more complex topics. Figure 30 shows a conceptual checkpoint quiz in Chapter 8 of Klein, *Organic Chemistry*. After introduction to the topic and interactive explanation (Figure 29), a conceptual checkpoint quiz was given in the interactive textbook to make sure students understood the basics before moving to the more complicated problems in the chapter.

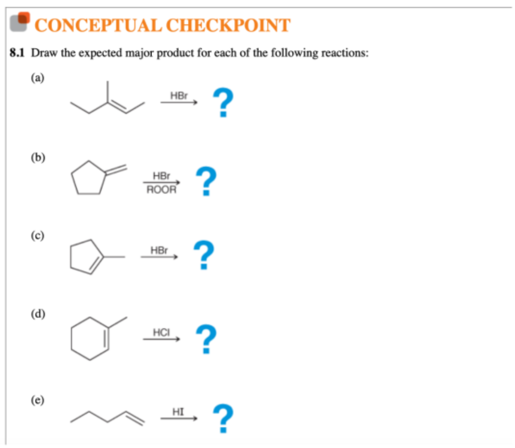


Figure 30: Conceptual Checkpoint from Section 8.04 of the online WileyPLUS course of Klein, Organic Chemistry, Wiley. Reproduced with permission from Wiley Publishing.

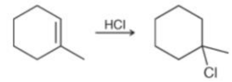
The lecture would next proceed to a series of worked examples followed by students attempting to do some examples on their own in group work or clicker quiz. After this, more complex examples would be worked and then the students would be given a peer instruction assignment. The interactive textbook next has a series of Skillbuilders (Figure 31) which mimics the study cycle used in the lecture. In the skillbuilder, a student is given a worked example (Learn the Skill), followed by some practice problems of the same exact type (Practice the Skill) and finally a more complex problem (Apply the Skill).

SKILLBUILDER

8.1 DRAWING A MECHANISM FOR HYDROHALOGENATION

LEARN the skill

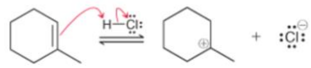
Draw a mechanism for the following transformation:



SOLUTION

In this reaction, a hydrogen atom and a halogen are added across an alkene. The halogen (Cl) is ultimately positioned at the more substituted carbon, which suggests that this reaction takes place via an ionic mechanism (Markovnikov addition). The ionic mechanism for hydrohalogenation has two steps: (1) *protonation* of the alkene to form the more stable carbocation and (2) *nucleophilic attack*. Each step must be drawn precisely.

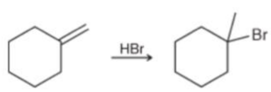
When drawing the first step of the mechanism (protonation), make sure to use two curved arrows:



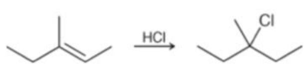
PRACTICE the skill

8.3 Draw a mechanism for each of the following transformations:

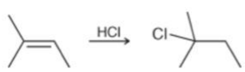
(a)



(b)



(c)



APPLY the skill

8.4 The bicyclo[3.1.0]hexane ring system, highlighted in compound **3**, is found in several natural products, including sabinene, a compound partially responsible for the flavor of ground black pepper. One method for preparing this ring system involves the conversion of compound **1** to compound **2**, as shown below.[1] Draw the structure of compound **2** and provide a reasonable mechanism for its formation.

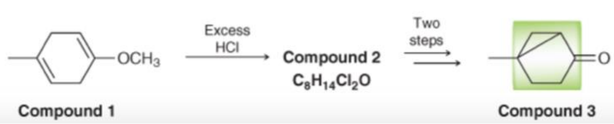


Figure 31: Skillbuilder from Section 8.04 of the online WileyPLUS course of Klein, Organic Chemistry, Wiley. Reproduced with permission from Wiley Publishing.

The interactive textbooks for both Klein and Solomons *Organic Chemistry* have been designed to help students achieve an ideal student study cycle by providing multimedia content and interactive quizzes and questions to facilitate a deeper understanding of the material. The instructional design of these courses was influenced at least partially by the design of the organic lecture at UNO, which accomplished the same goals using clicker quizzes, anecdotes, peer instruction and other forms of active learning.

7.7 Student's Evaluations of Pedagogical Changes

Starting around 2010, student evaluations (in addition to the university evaluations) were done each semester on every organic cohort. The evaluations asked specific questions about the teaching pedagogy and its impact on the students (Appendix 2). The data collected from the last cohort (fall 2016/spring 2017 organic students) taught by the author was analyzed to show student's perceptions of pedagogical changes and the impact of those pedagogical changes on those students.

The organic chemistry 1 cohort, fall 2016, had 81 students take the end of semester survey (although some of the later questions only had 80 responses as 1 student only took first half of survey before quitting). The organic chemistry 2 cohort, spring 2017, had 60 students take the end of semester survey. The spring semester survey added a few questions about active learning that were not in the fall semester, but otherwise the surveys were identical. Organic 1 students expected that they would get a final grade of A- (GPA 3.6) and 60% of the students were traditional students, which meant they took organic chemistry right after (or within a semester or two of general chemistry. These were not students returning to school after graduating previously and they were not repeat students. The other 40% of students fell into the returning students or repeat students.

Organic 2 students expected that they would get a final grade of B+ (GPA 3.4) and 89% of the students were traditional students. The higher expected GPA in organic 1 is not unexpected since the course is seen as a simpler course (figure 32). The larger number of traditional students in organic 2 is also expected since most of those students progressed from organic 1 to organic 2 (figure 33). In actuality, the GPA for organic 1 was 3.33 (compared to self-reported 3.6) and the GPA for organic 2 was 3.51 (compared to self-reported 3.4). Organic 1 overreported by 7.5% and organic 2 students underreported by 3.2%. These were prior to the final exam and within a statistical acceptable difference indicating the rest of their replies should be reliable statistically.

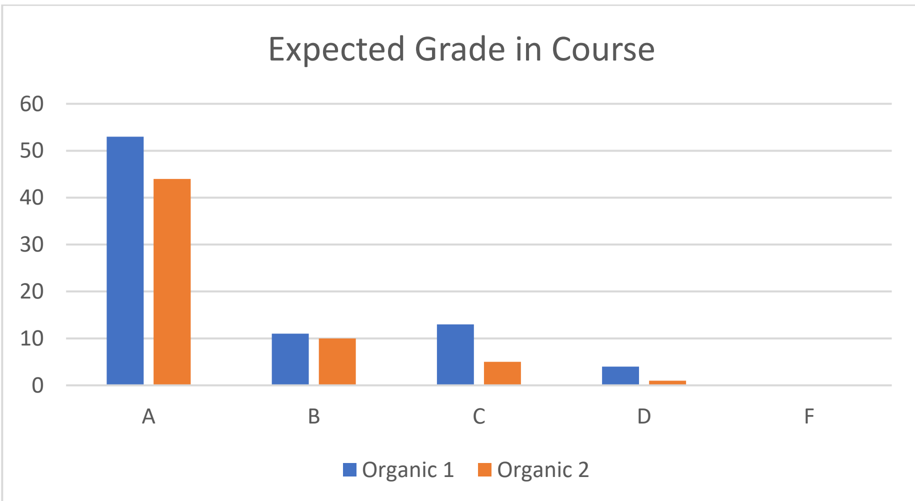


Figure 32: Expected Grade in Course (Organic 1 = 3.6; Organic 2 = 3.4). Y-axis is Number of Students (Organic 1, N = 81; Organic 2, N = 60)

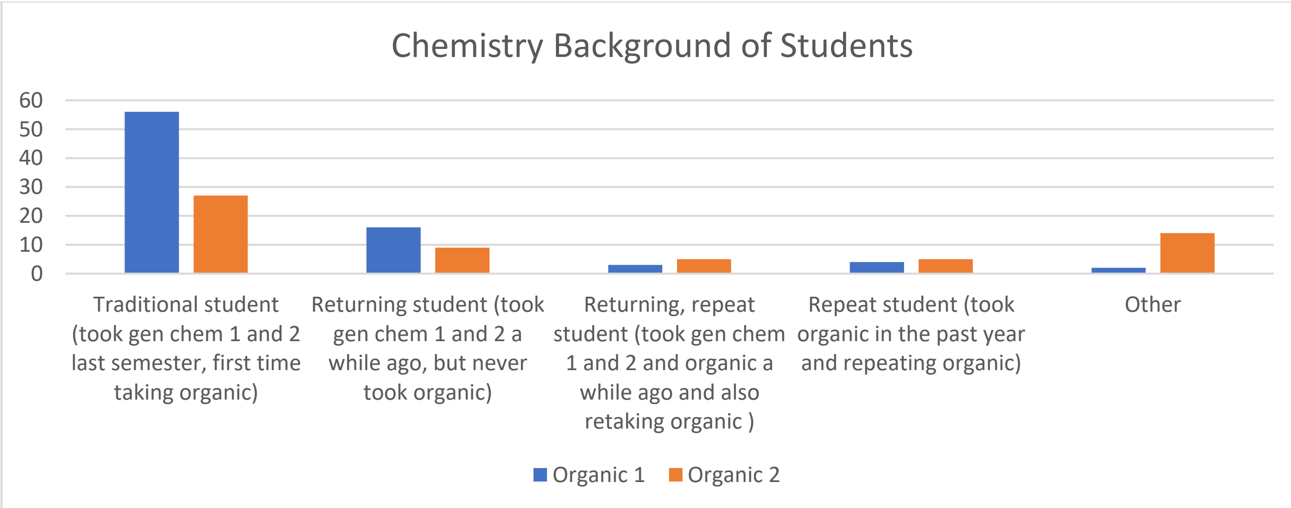


Figure 33: Chemistry Background of Students. Y-axis is Number of Students (Organic 1, N = 81; Organic 2, N = 60)

85% of Organic 1 students study habits stayed the same (32%) or improved (53%) throughout the semester, while 15% said their study habits regressed. Conversely, 97% of the organic 2 students say their study methods stayed the same (35%) or improved (62%) throughout the semester, while only 3% said their study habits regressed (figure 34). Organic 2 students are more mature; the organic 2 course is tougher, and they already survived organic 1 so it is unsurprising that their study habits experienced much less regression.

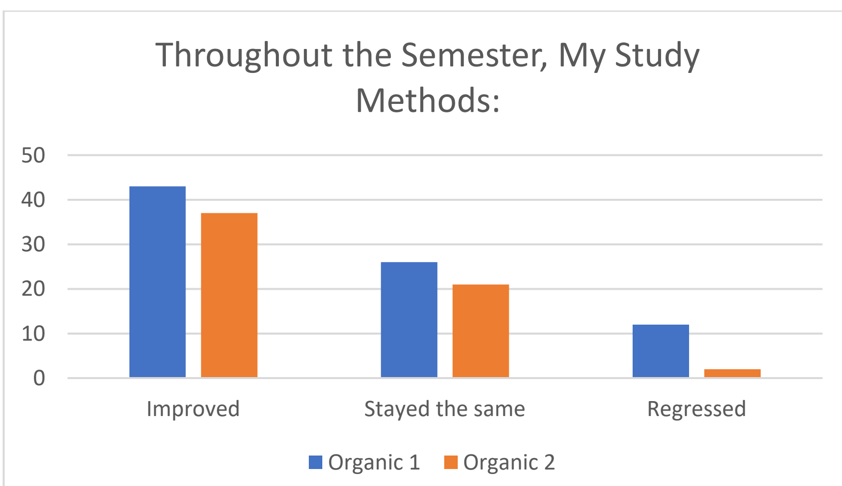


Figure 34: Study Methods Progression Throughout Semester. Y-axis is Number of Students (Organic 1, N = 81; Organic 2, N = 60)

Students had a large variety of study aids (practice tests, lecture study guides, lecture videos, textbook, online resources) available to them. Students in both semesters ranked practice tests, lecture study guides and lecture videos as the most used study aid (figure 35) for their success in the course. The organic 1 students ranked study groups and online resources (Google, Khan academy…) as the next most used study aids while organic 2 students ranked textbook and recitations as the next most often used study aids. Students in both groups ranked online homework as one of the least used study aids. Organic 1 students found recitations the least useful to them. Organic 2 students ranked online resources as not useful at all.

Since a large part of organic 1 involves conceptual knowledge (nomenclature, stereochemistry…), it is logical that the fellow students (study groups) and turning to online resources (Kahn academy, Google…) were more important to organic 1 students than organic 2 students. Most of organic 2 involves reactions, mechanisms and synthesis, since these are more complex materials that cannot be memorized and are also very specific to the course, the textbook and recitations were more important to organic 2 students. Recitations received zero votes from organic 1 students, indicating that recitations were not helpful for organic 1 students but were ranked much higher by organic 2 students. This could be because of the material but also could indicate that recitations were deemed more important to students who were more mature, had better study habits and realized the benefits of doing practice problems in a group with dedicated help available to them.

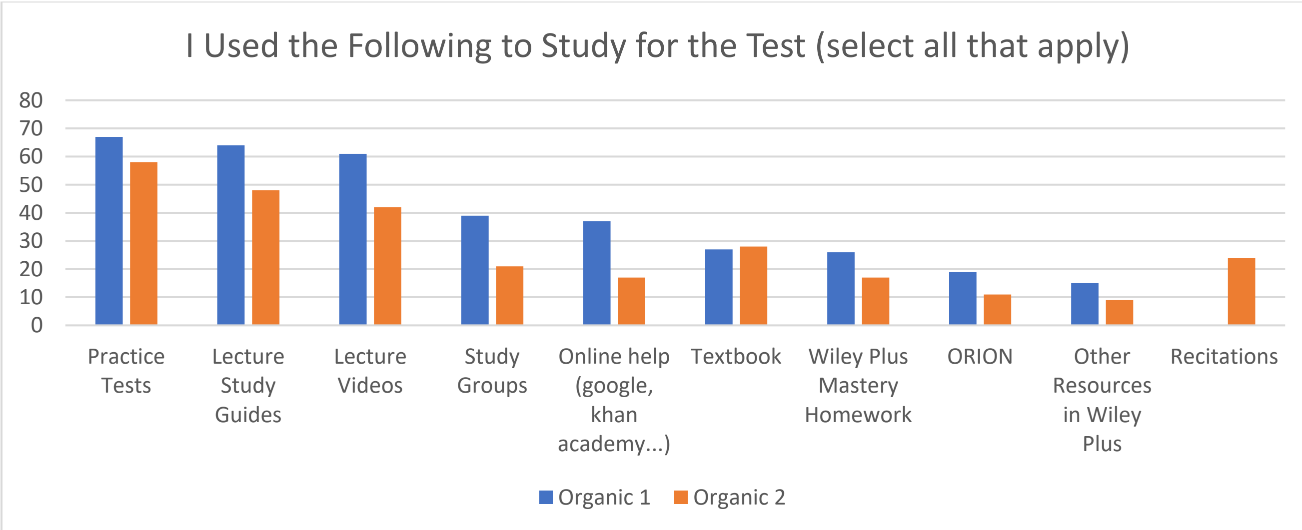


Figure 35: Most Used Study Aids Fall 2016 and Spring 2017. Y-axis is Number of Students (Organic 1, N = 81; Organic 2, N = 60); Longer Bars Indicate More Used Study Aids

Students were also asked to rank the various study aids from most important to least important (figure 36). Unlike the previous questions where students could select all study guides that were useful, in this question the students were asked to decide on the most important study aids not the most used. Practice tests, lecture study guides and lecture videos were again the top three choices from the student. Practice tests were ranked 1st by both groups of students for both questions. While lecture study guides were ranked 2nd by both organic 1 and organic 2 as the most used study method, lecture videos were ranked 2nd by both organic 1 and organic 2 students as the most important. Additionally, this question had a much higher correlation between cohorts. Both cohorts had identical top 4 (practice test, lecture videos, lecture study guides and textbooks). Both had recitations and mastery homework next (with the order flipped between cohorts) and both had ORION and online help last (with the order flipped between cohorts). Unfortunately, study group was inadvertently left off of the organic 1 survey so a comparison of how organic 1 and 2 students ranked using a study group could not be made. Based on these results, it seems that the type of material (conceptual for organic 1 and reactions for organic 2) had an effect on the most used study aid; but, it had less of an effect on most important study aid.

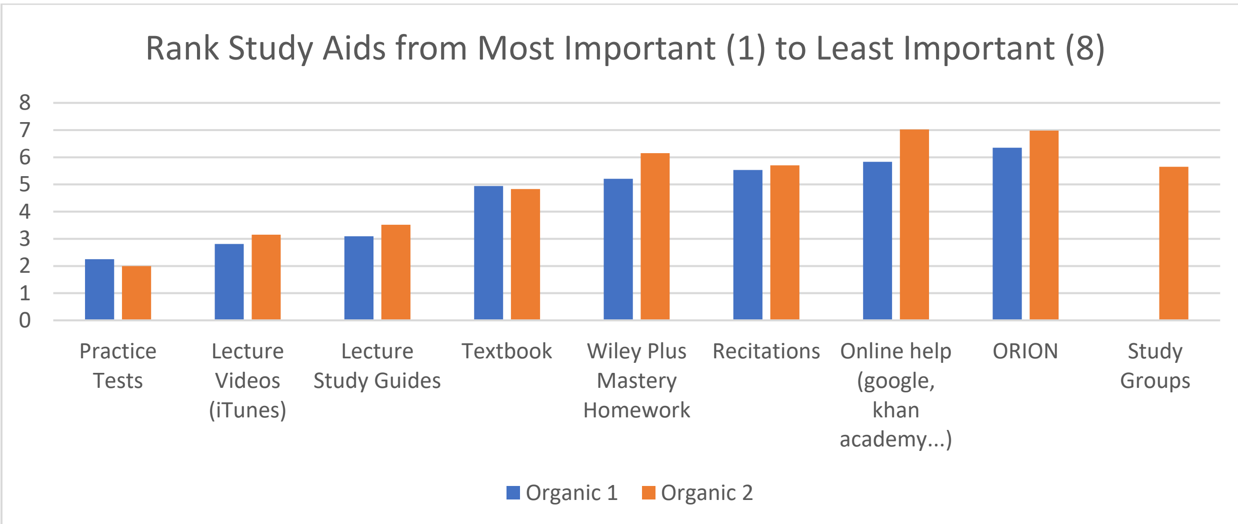


Figure 36: Most Important Study Guides. Y-axis is Average Ranking; Shorter Bars Indicate More Important Study Aids. Study Groups was not Listed (by Mistake) for Organic 1 Students

Finally, students were asked to rank the usefulness of each study aid (figure 37) using a Likert scale (extremely useful, very useful, useful, somewhat useful, not useful at all). For both organic 1 and 2, the top three were practice tests, lecture videos and lecture study guides. Mastery was 6th for both and ORION was last for both. With online help and textbook ranking 4th and 5th for organic 1 and textbook and recitations ranking 4th and 5th for organic 2. Based on these three questions (figures 35-37) it is clear students find practice tests, lecture videos and lecture study guides most useful.

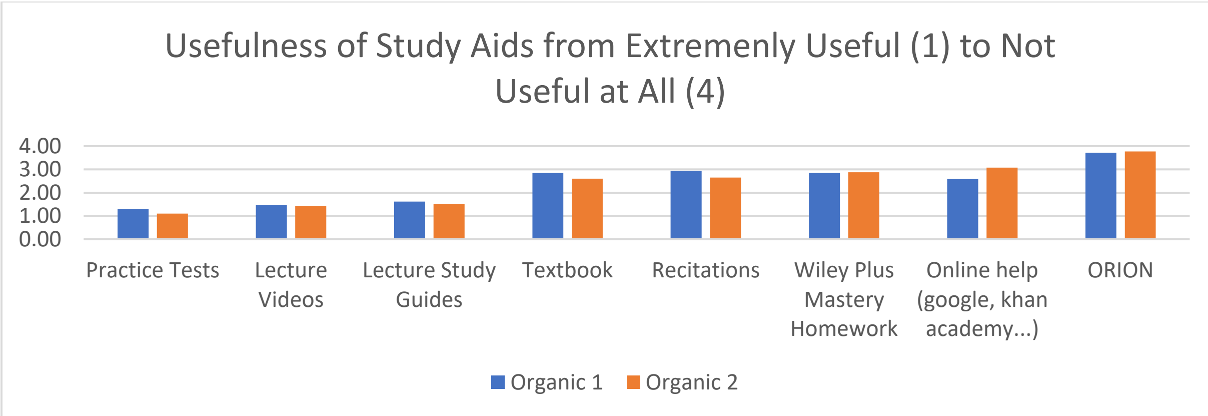


Figure 37: Most Useful Study Guides. Y-axis is Average Usefulness; Shorter Bars Indicate More Important Study Aids

Comparing the rankings of used, importance and usefulness by cohort and the overall average (figure 38), confirms that students have a definite preference for practice tests, lecture videos and lecture study guides. The textbook and recitations are next in importance and online resources are last in importance.

Ironically, the most important study aids for the student were the easiest and least time consuming to create for the faculty. Most faculty have old tests that they can put up on the university LMS (Learning Management System, such as Moodle, Canvas, D2L, Blackboard). Most faculty have also created lecture notes that can be converted to PDF and given to students. Recording of videos (chapter 5) is very easy to do with modern screen capture programs. Screen capture can be done with the simple push of one button (record) at the beginning and end of lecture (stop). The screen capture needs to be saved and compressed (couple of more button pushes) and uploaded to the LMS (or some other online drive, Dropbox, Google, iTunes U). For the organic lectures, saving of screen capture and compression took about 10 minutes of post-lecture time (most of which involved the program compressing and exporting the file).

But the benefits (figures 35-38) of making this simple change vastly outweighed the effort exerted to make the change.

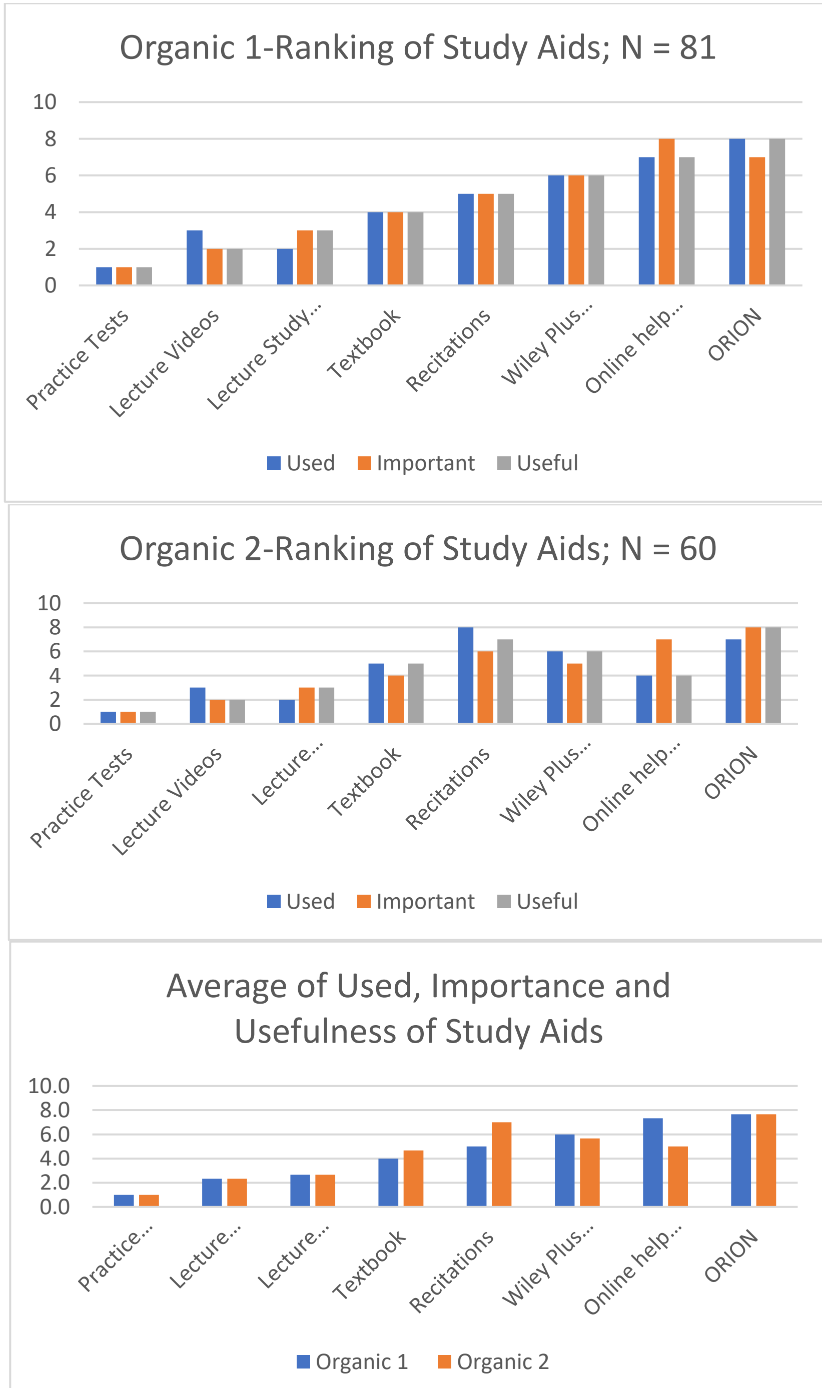


Figure 38: Organic 1 (top) and Organic 2 (center) Ranking of Study Aids by Question; Average Ranking of All Study Aids By Organic 1 and 2 Students (bottom). Y-axis is Average of Ranking; Shorter Bars Indicate More Important Study Aids

Based on the results of the survey, online resources and recitations were not as important or useful to the students as had been hoped. Were the other study aids so beneficial that even though online resources and recitations were useful, they just were less useful and important than other study aids or were the online resources and recitations not useful and should be modified or abandoned? Figure 38 seems to suggest the latter. The usefulness (or lack of usefulness) of online resources and recitations was not unexpected based on student comments and complaint throughout the semester. Because of this, questions were added to the survey to dig deeper into the online resources and recitations.

Students were asked four additional question about WileyPLUS. First, they were asked if WileyPLUS helped them study for the tests (figure 39). Next, they were asked which feature helped them study for the test most (figure 40). Then, they were asked to rank the features of WileyPLUS from most important to least important (figure 41) and finally, they were asked how useful each feature of WileyPLUS was for understanding the material and studying for the test (figure 42).

59% of organic 1 students found WileyPLUS helped them study while 41% said it did not help. 63% of organic 2 students found WileyPLUS helped while 37% said it did not help. There was little statistical difference between the two cohorts. Roughly 6 out of 10 students felt WileyPLUS helped them study.

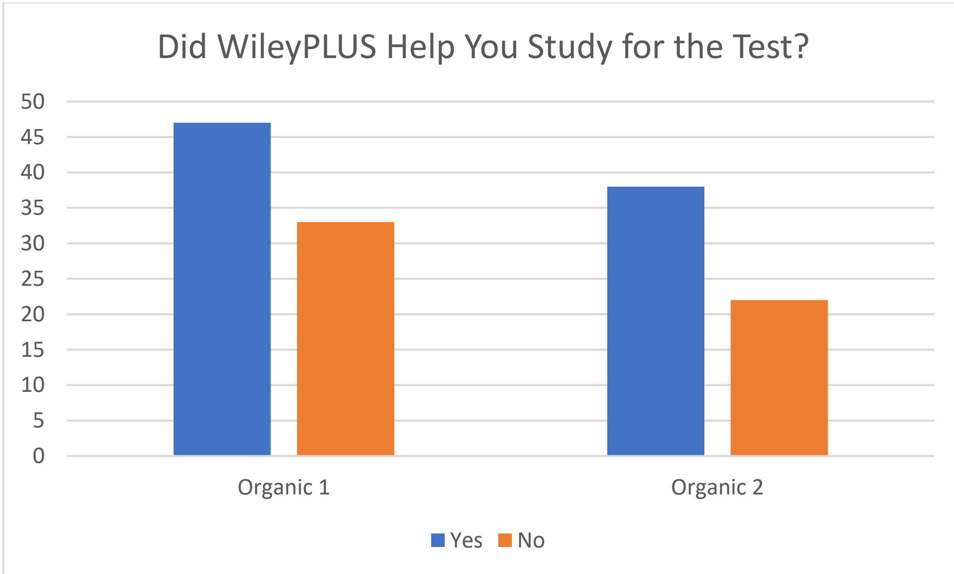


Figure 39: Number of Students that Said WileyPLUS Helped Them Study. Y-axis is Number of Students (Organic 1, N = 80; Organic 2, N = 60)

Specifically, students found the mastery assignments in WileyPLUS to be the most helpful feature of the online system. This was followed by the e-book/videos and then the pre-lecture quizzes. Mastery assignments are 10 question homework assignments. Students get only one attempt per question after which they are given the solution and feedback. Mastery assignments have three possible grades. Students received a 10/10 if they get 8-10 questions correct. They received a 5/10 if they get 5-7 questions correct and a 0/10 if they get 0-4 questions correct. Students may retake the assignment (with new questions each time) as many times as they like to achieve their highest grade. Mastery was rated most helpful by 43% of organic 1 students and 45% of organic 2 students.

The eBook is an online version of the textbook that has videos and practice questions embedded within the textbook. Students can access this via laptop, tablet or phone. 25% of organic 1 students and 32% of organic 2 students said that the eBook was the most helpful. The top two features (mastery assignments and eBook) were chosen by 68% of organic 1 students and 77% of organic 2 students. These features ranked about one standard deviation above the bottom two features and ½ to ¾ of a standard deviation above pre-lecture quizzes.

Pre-lecture quizzes are static (non-pooled, non-algorithmic) 10 question quizzes due one hour before lecture to make sure the students had read the material prior to coming to lecture. 18% of organic 1 students and 10% of organic 2 students said that the pre-lecture quiz was the most helpful. ORION is an adaptive learning system, where students take a diagnostic quiz that sets their base level of proficiency in a chapter. Based on their diagnostic quizzes, students are given questions that match their proficiency level. 9% of organic 1 students and 7% of organic 2 students said ORION was most helpful. Mechanism explorer questions test students ability to draw mechanisms. 6% of organic 1 students and 7% of organic 2 students said mechanism explorer was most helpful.

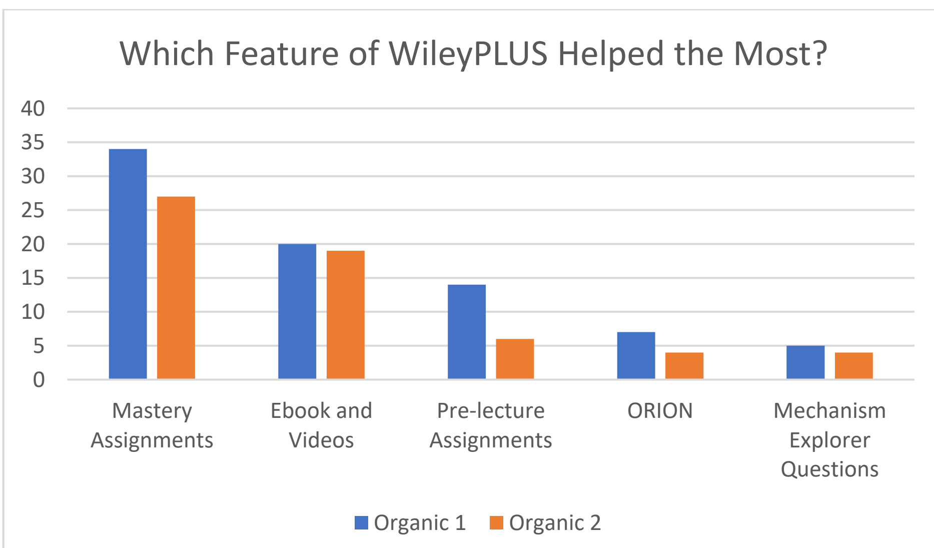


Figure 40: Helpful Features of WileyPLUS. Y-axis is Number of Students (Organic 1, N = 81; Organic 2, N = 60); Longer Bars Indicate More Helpful Features of WileyPLUS

Students were also asked to rank the five features of WileyPLUS from most important to least important. This ranking yielded one surprising result. The top two still were one standard deviation better than bottom two. While mastering was still ranked the most important, pre-lecture quizzes overtook the eBook in terms of importance and ranked about a half standard deviation higher than the eBook. Mastering was over one standard deviation higher than the bottom two features of WileyPLUS and about one standard deviation above the eBook and ½ a standard deviation above pre-lecture quizzes.

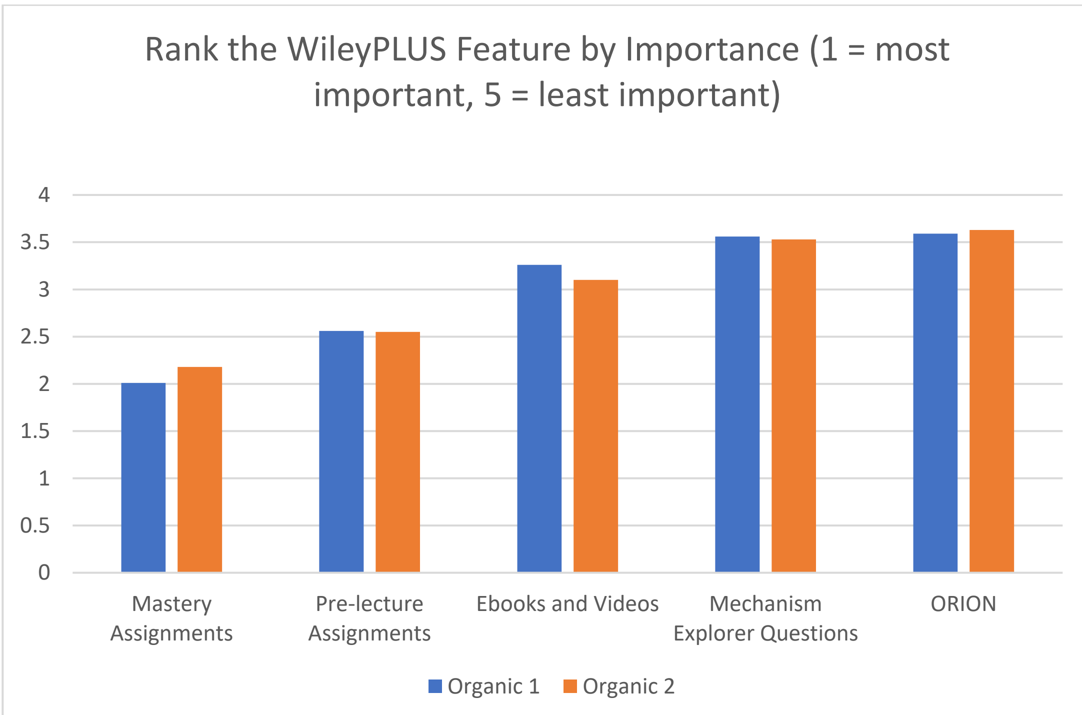


Figure 41: Ranking of WileyPLUS Features by Importance. Y-axis is Number of Students (Organic 1, N = 81; Organic 2, N = 60); Shorter Bars Indicate More Important Features of WileyPLUS

Lastly, students were asked to rank how useful each feature of WileyPLUS was for helping students understand the material. The order of features were identical to the previous questions but the difference between each feature shrunk considerably. Mastering was almost identical to the second (pre-lecture quizzes) choice but ½ a standard deviation above the third (eBook) and fourth feature (mechanism) and a full standard deviation above the lowest performing feature (ORION).

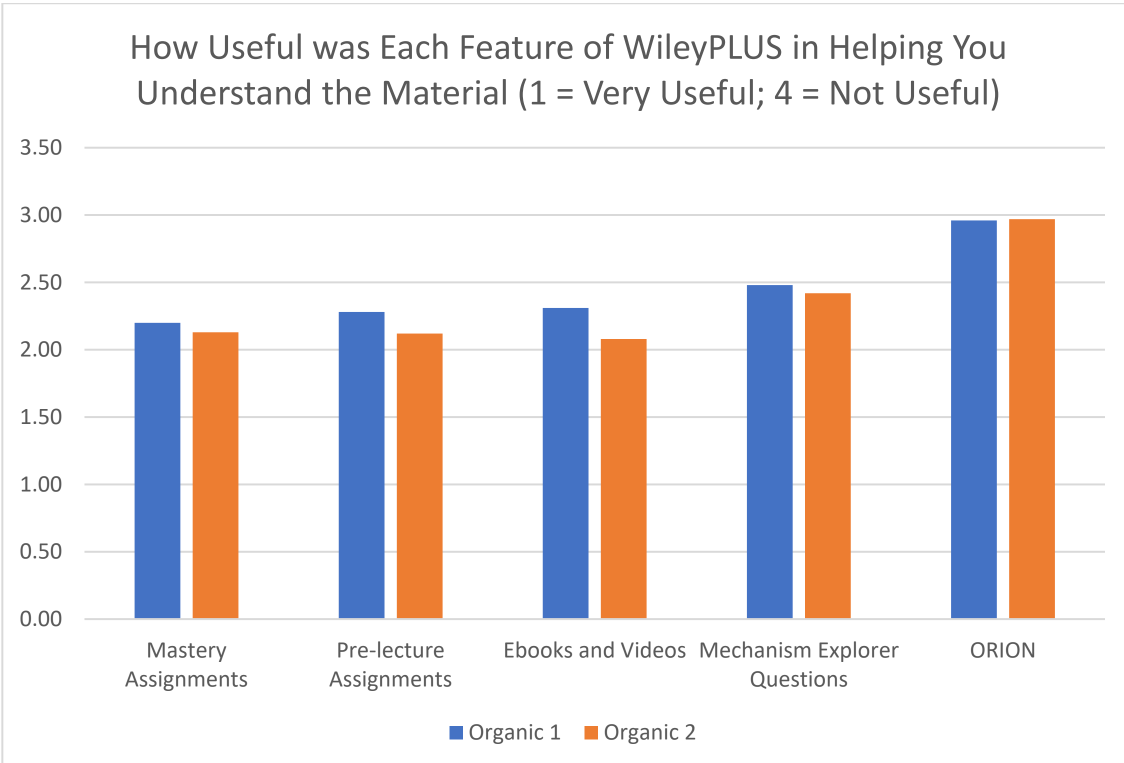


Figure 42: Usefulness of Each Feature of WileyPLUS. Y-axis is Number of Students (Organic 1, N = 81; Organic 2, N = 60); Shorter Bars Indicate More Important Features of WileyPLUS

Overall, the results of the survey showed that students did find WileyPLUS helpful, just not as helpful as the practice tests, lecture videos and lecture study guides. Based on the results of the surveys, students preferred the mastery and pre-lecture assignments in WileyPLUS along with the available eBook but did not think the mechanism explorer or ORION provided usefulness to their learning but actually took time away from their studying. The professor also noted that the mastery assignments and pre-lecture assignments seemed to be the best for the students while ORION and mechanism explorer did not seem to provide any benefit. In future semesters, WileyPLUS should be retained in the course, but only mastery and pre-lecture assignments should be used in the course.

The students were asked three questions about recitations. The first question asked how often they attended recitations (figure 43). The second question asked what part of recitation was most helpful (figure 44) and the third question asked about the undergraduate TA's knowledge, preparedness and so forth (figure 45). Most students self-reported that they attended all (or all but one or two) of the recitations (88% for organic 1 and 87% for organic 2). Based on final recitations grades from the TA, these are probably inflated just a little but fairly accurate self-reporting.

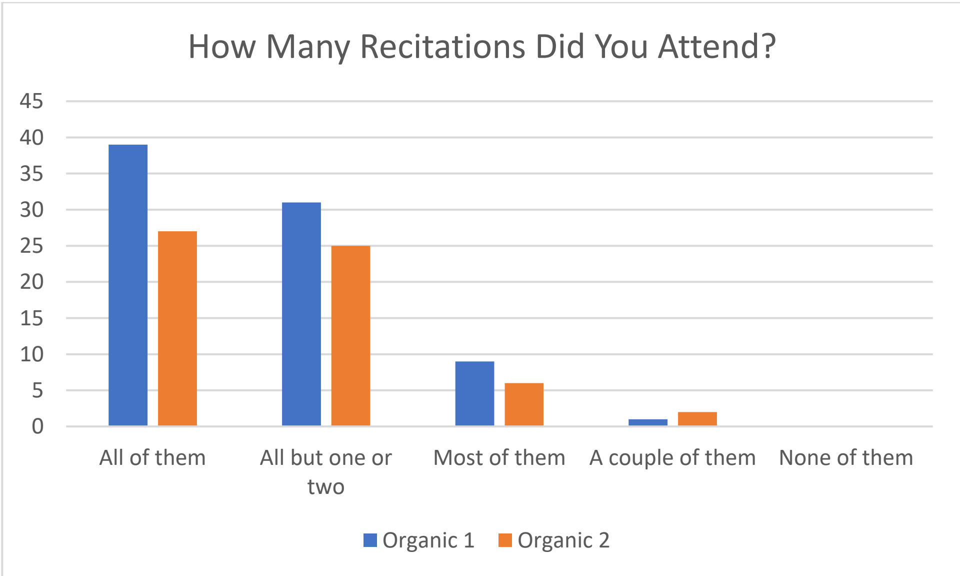


Figure 43: Attendance in Recitation. Y-axis is Number of Students (Organic 1, N = 80; Organic 2, N = 60)

When asked about the effectiveness of recitations (students could select all that apply), 60% of organic 1 students and 62% of organic 2 students thought working problems was a big help. 50% of organic 1 and 58% of organic 2 students thought the TA was very helpful. 31% of organic 1 and 30% of organic 2 students thought group problem solving was a big help. 7.5% of organic 1 and 10% of organic 2 students thought that recitations could have been helpful, but they did not take proper advantage of the recitations. Finally, 28% of organic 1 and 35% of organic 2 students thought that recitations were a waste of time. Overall satisfaction with recitations seems to be around 60-70% (figure 44). The two semesters had extremely similar responses indicating a strong agreement with recitation effectiveness across semesters and courses.

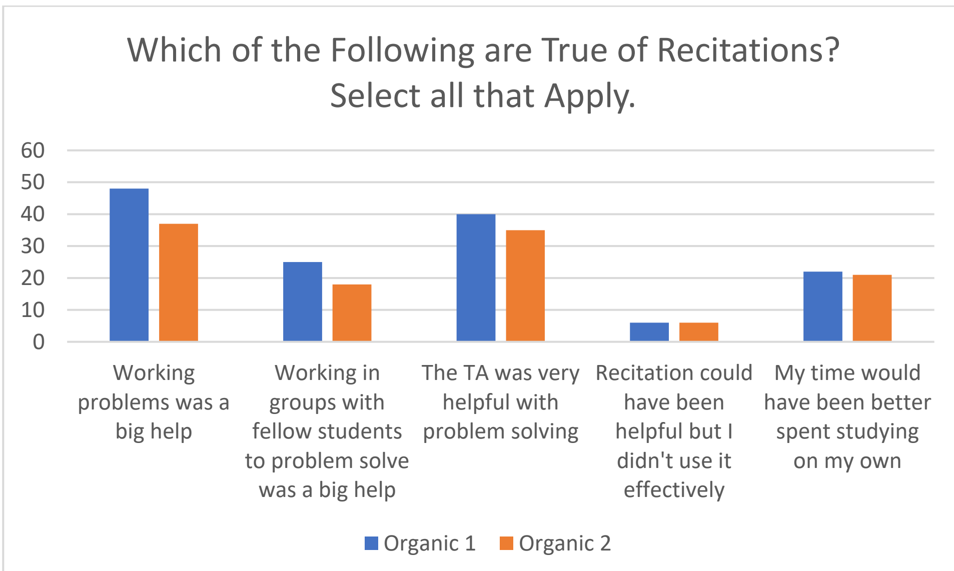


Figure 44: Satisfaction with Aspects of Recitations. Y-axis is Number of Students (Organic 1, N = 80; Organic 2, N = 60); Longer Bars Indicates More Satisfaction with the Statement

Finally, students were asked to rate their undergraduate TA on various factors. In general, the undergraduate TA received very high marks from the students. The students used a Likert scale from strongly agree = 1 to strongly disagree = 5. Students ranked the undergraduate TA preparedness a 1.60/1.62 for organic 1 and 2 respectively. Students ranked the undergraduate TA knowledge 1.71/1.65 for organic 1 and 2 respectively. Students ranked the undergraduate TA helpfulness 1.80/1.58 for organic 1 and 2 respectively. Students ranked the undergraduate TA willingness to help 1.44/1.38 for organic 1 and 2 respectively. Finally, students ranked the undergraduate TA helpfulness with hardest concepts 1.86/1.70 for organic 1 and 2 respectively. There was great similarity in results for both semesters and undergraduate TA ranked very highly averaging a 1.68 for organic 1 and a 1.59 for organic 2. These equate to a 4.32/4.41 on a faculty student evaluation, which is a very good rating.

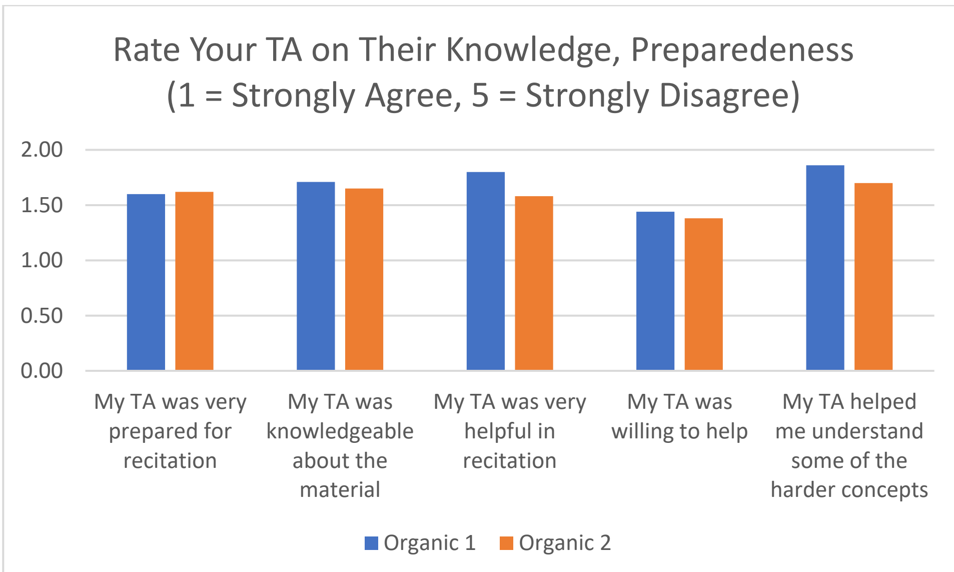
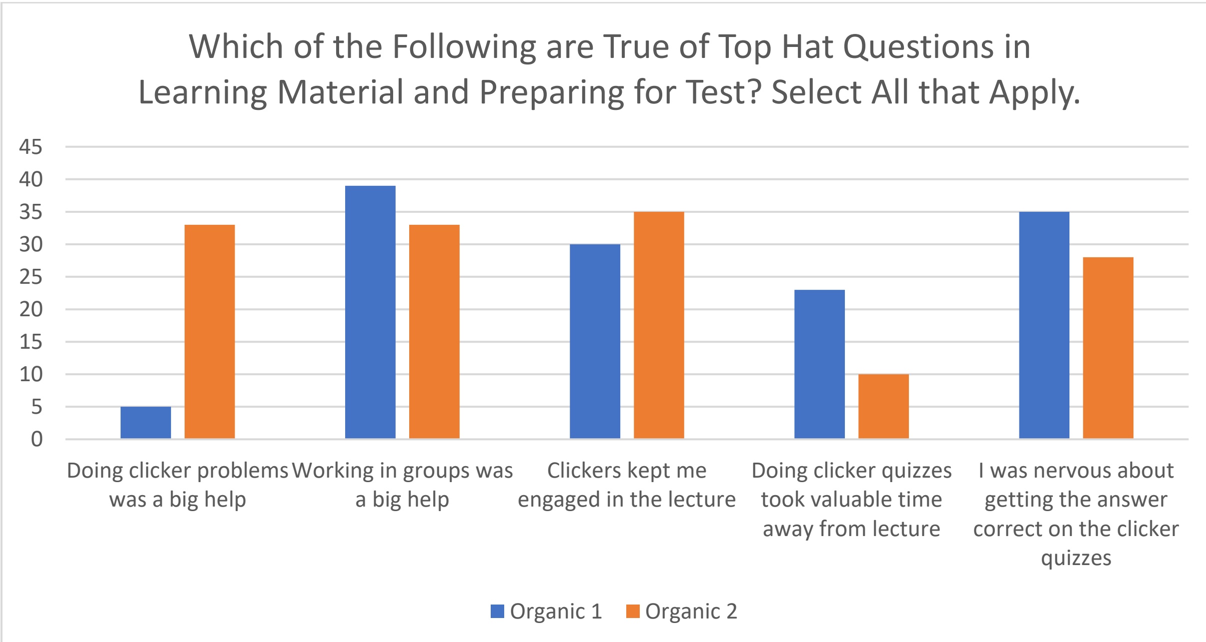


Figure 45: Ranking of Undergraduate TA. Y-axis is 1-5 on Likert Scale; Shorter Bars Indicate More Agreement with Statements

Both cohorts of students were asked about their opinion of the effectiveness and use of active learning clicker quizzes (figure 46). The spring cohort of organic 2 students was also asked four follow up questions about active learning (figures 47-49). They were first asked about the amount of active learning in the classroom. Next, they were explained what a flipped or hybrid classroom is and asked their opinion on the use of flipped classroom for organic chemistry. They were then asked to pick topics that they thought could be learned outside of the classroom using videos and other methods. Finally, they were asked to give any thoughts on flipped classrooms.

Some questions had a good agreement between cohorts, while other questions had a huge variance between the cohorts. For example, 6% of organic 1 students thought clicker quizzes were a big help compared to 55% of organic 2 students. Organic 1 student also thought clickers took valuable time away from lecture more than organic 2 students (29% to 17%), kept them engaged less in lecture (38% to 58%), liked the frequency of the clicker quizzes (13% versus 25%) and wanted clickers used more for engagement instead of quizzes (40% to 25%) when compared to organic 2 students. However, organic 1 students wanted more clicker quizzes (35% to 18%) than organic 2 students and did not want fewer clicker quizzes than organic 2 students (8% to 17%). These last two questions are completely counterintuitive since only 6% of organic 1 students thought they were helpful but 35% wanted more clicker quizzes.

Both organic 1 and organic 2 agreed on a number of questions. Specifically, 49% of organic 1 and 55% of organic 2 students thought that working in groups while solving the clicker quizzes was extremely helpful. Both groups of students were nervous about getting answers correct (44% and 47%, respectively), wished there were shorter, more frequent quizzes (15% and 12%). Overall, all students enjoyed the group work part of the clicker quizzes and the organic 2 students realized (much more than organic 1 students) the value of the clicker quizzes for helping to prepare for tests and keeping engaged in lecture (figure 46).



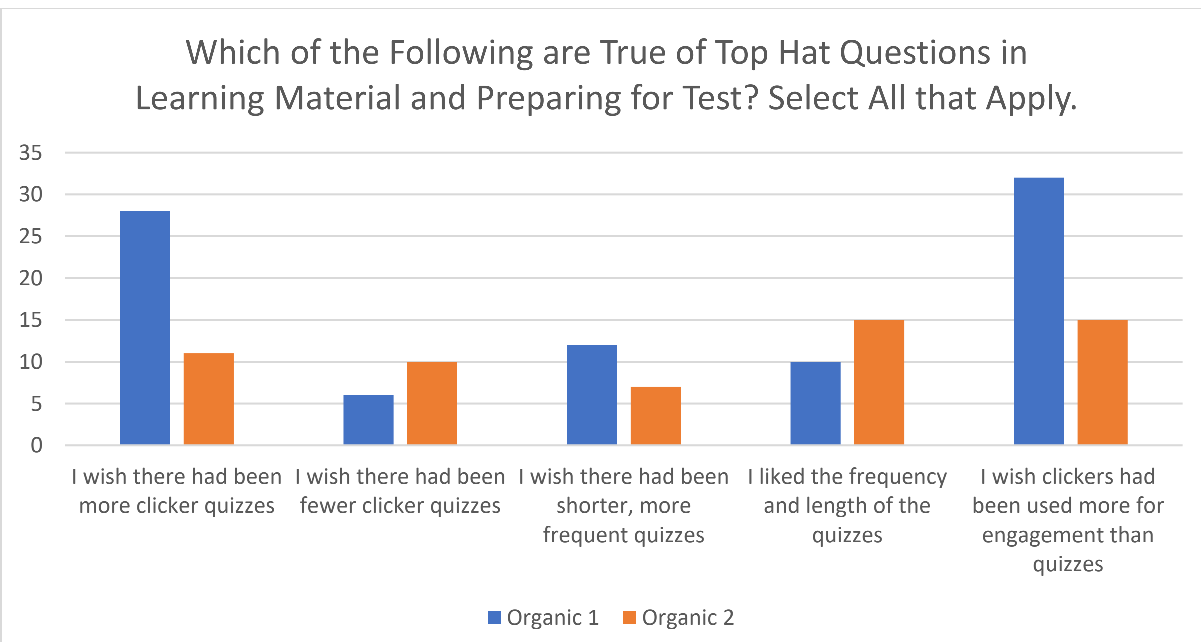


Figure 46: Survey of Top Hat Clicker Quizzes. Y-axis is Number of Students (Organic 1, N = 80; Organic 2, N = 60)

The organic 2 cohort (spring 2017) was asked about the use and amount of active learning in the classroom. 55% of the students thought there was just the right amount of active learning. 32% thought some lectures has the right amount but others did not. 12% said there was not enough active learning and 2% thought there was too much active learning. These are very encouraging results. 98% of students thought there was the right amount or could use more active learning, while only 2% thought there was too much active learning.

These results correspond very well with the faculty member's thoughts on active learning. Overall, it was thought that active learning was used very effectively in the class, but there were some lectures where there was no active learning and should have been and there were some lectures where there was too much active learning. These are easily fixed problems that can be corrected by a recalibration of the amount of active learning and simply having greater experience in using active learning in the classroom.

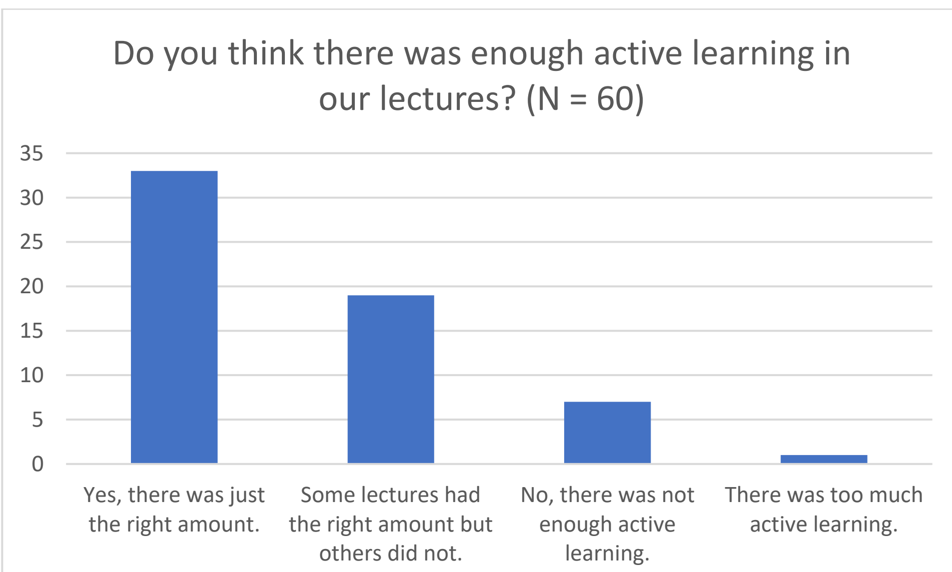
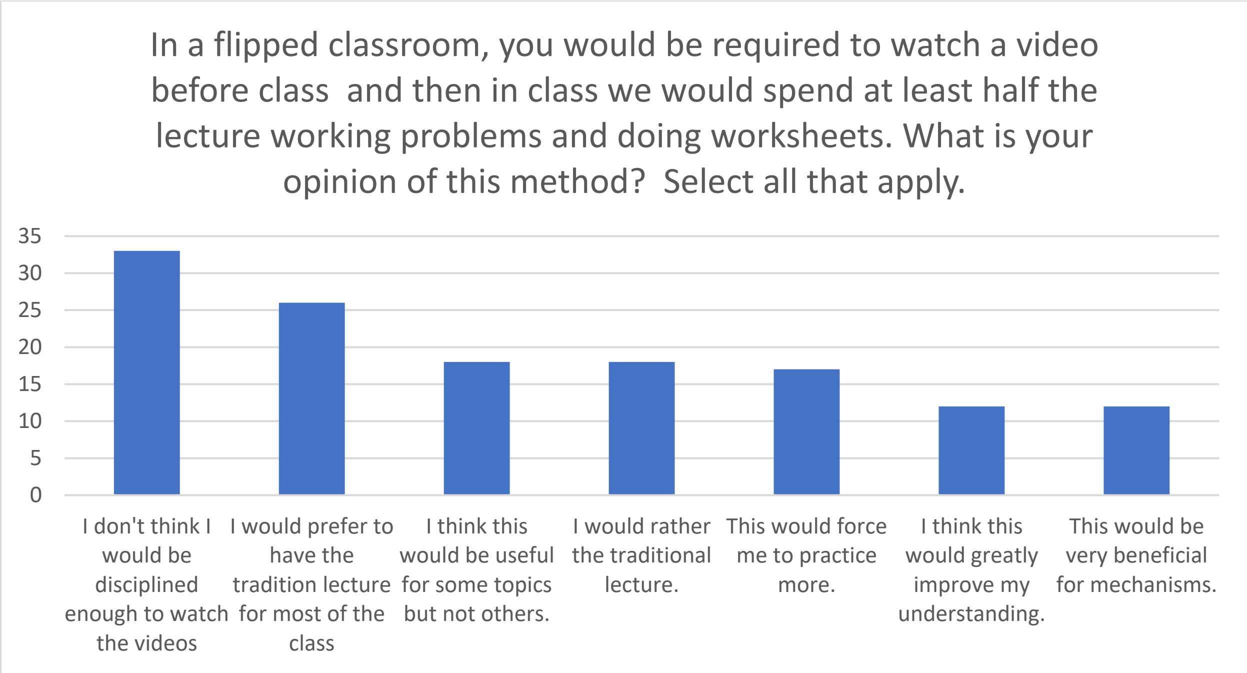


Figure 47: Active Learning Survey. Y-axis is Number of Students (N = 60)

The next question the students were asked about active learning was about the use of a fully flipped or hybrid lecture in the organic chemistry classroom. Students were explained what a flipped or hybrid lecture would look like and then asked their opinion of the use of this in the classroom. 55% of students thought they would not be disciplined enough to watch the videos, 43% would prefer a traditional lecture for most of the class, 30% would prefer a traditional lecture for all of the class, 30% thought it would be useful for some topics but not for others. These four results suggest that the flipped classroom would meet some resistance from students. But it could be used for some very specific topics and could be useful.

28% of students thought that a flipped class would force them to practice more. 20% thought it would both greatly improve their understanding of material and would be very beneficial for mechanisms. 17% thought that a flipped class would improve both their time management and that their grade would improve in this environment. 12% said they would attend class more in a flipped classroom and 5% would attend class less. 10% said their grades would decrease in a flipped classroom (figure 48).

Overall, the results of this survey question suggest (at least amongst this cohort) that a flipped classroom may not be a welcome addition. The students do see potential value for this type of pedagogy and understand that it would require more pre-lecture work from them (but less post-lecture work). There are certain topics where this would be a better fit than for other topics. Based on both the student experience and the faculty experience, a flipped classroom is not warranted at this time. However, a hybrid or partially flipped classroom, where some topics are pushed out of the lecture and more lecture time is spent on active learning, was indicated to be a desirable pedagogy by both students and faculty.



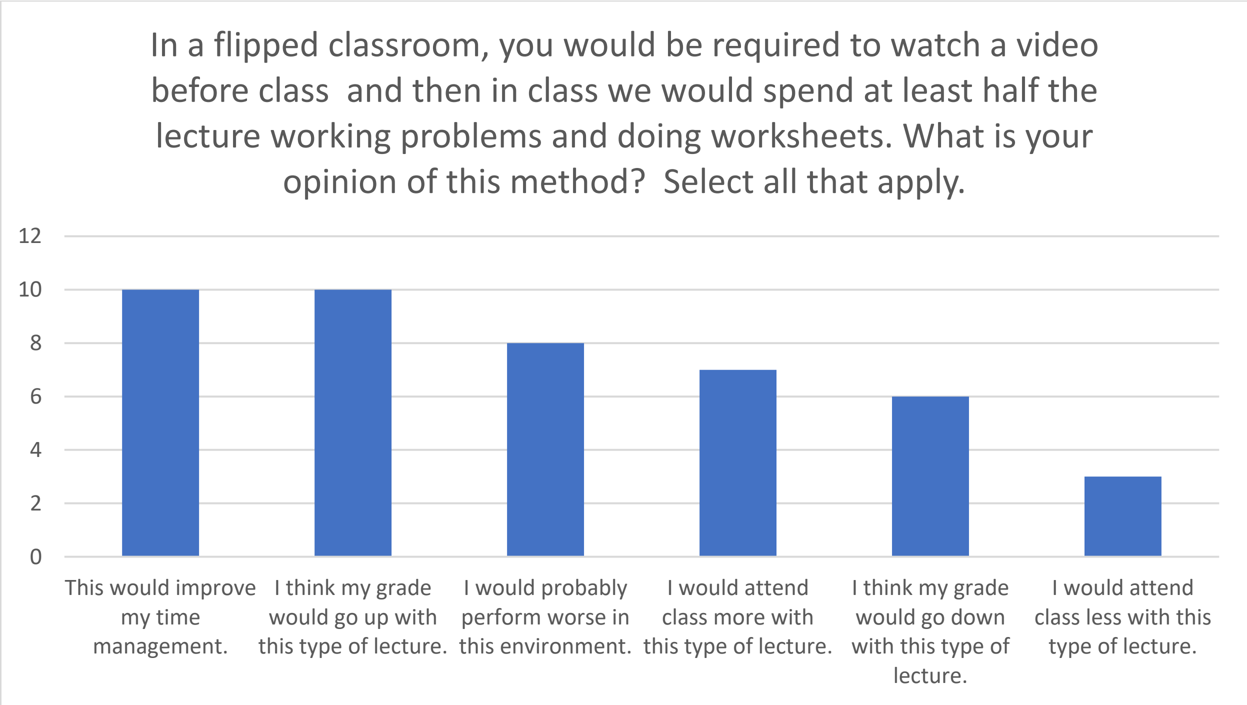


Figure 48: Survey of Flipped Classroom. Y-axis is Number of Students (Organic 2, N = 60)

Whether using a flipped, partially flipped or traditional lecture with active learning, some topics must be removed from the lecture. The next question on the survey asked the students to pick which topics they thought could most easily be taught outside of lecture (figure 49). Students were given potential topics from organic 1 and organic 2 that could be taught using a flipped approach. The choices of potential topics for this question were picked by the faculty based on which topics could most easily be moved out of the lecture for students to learn with videos and worksheets prior to coming to class.

According to the survey, the organic 1 topics that would most easily be removed from the lecture were found in chapters 1-3. 63% of students selected all of the general chemistry review found in chapter 1. Students also picked individual parts of chapter 1 as topics easily removed from the lecture. Specifically, chemical bonding (28%), Lewis structures and formal charges (27%), constitutional isomers (12%), quantum mechanics (12%) and hybridization (17%) all received substantial support to remove from the lecture. From chapter 2, covalent bonds and dipole moment (18%), functional group identification (17%) and physical properties (13%) also received substantial support to remove from the lecture. As did pK_a (17%), acidity and basicity trends (13%) and acid-base properties (13%) from chapter 3.

The rest of organic 1 received lower vote totals for the most part. For chapters 4-11, introduction to nomenclature (13%), NMR/MS background (12%), physical properties of alkanes (10%), nomenclature of alcohols (10%), IHD (8%), %ee (8%), everyday radical reactions (8%) and general stereochemical properties (not including R and S) (3%) received lower support for removal from the lecture. Based on teaching experience and other factors, the faculty felt that the topics most easily removed would be general chemistry review from chapters 1 and 2, acid-base properties and nomenclature. The survey results corroborated this assumption with those topics receiving the highest vote totals from the students for removal from the course.

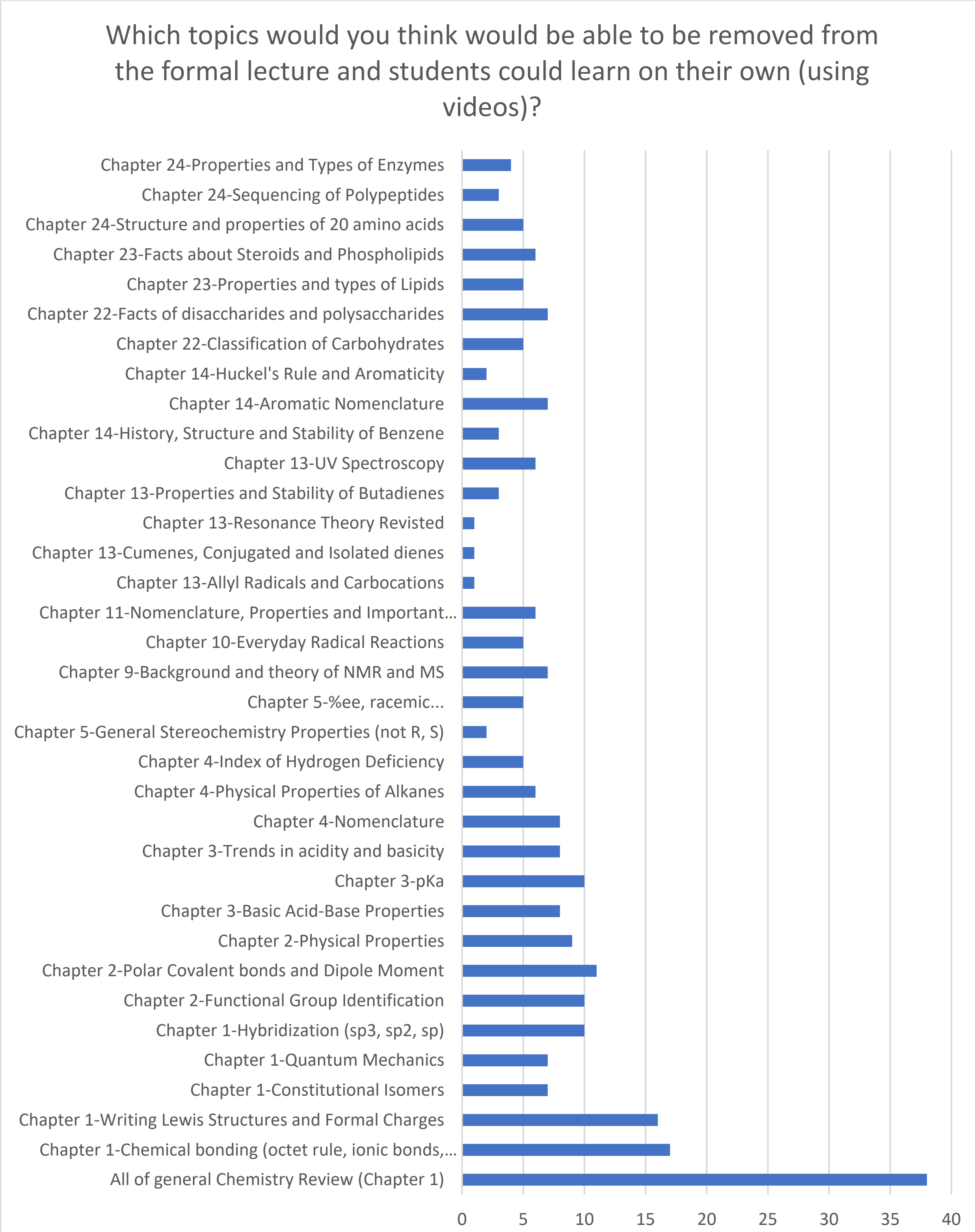


Figure 49: Topics to Remove via Flipped Learning. X-axis is Number of Students (Organic 2, N = 60)

The final active learning question was an open-ended essay question to give students a chance to give comments on the flipped classroom. 36 of the 60 students chose to make a comment. 29 of those comments were against converting the lecture to a flipped classroom model and 7 supported changing to a flipped classroom model. Below are listed some of the responses.

Sampling of responses against changing to a flipped classroom (only edited for typos):

> Dr. Hickey is an amazing professor, his traditional lecture is already productive in teaching. I don't think anything should change.
>
> I feel like very few students would actually follow through and do the pre lecture.
>
> Lecture as it was during this semester was just about right. Not too much of everything such as top hat or quizzes in class, but still enough for students to comprehend certain topics.
>
> I think spending more than 20% of lecture time on working problems would be a bad idea except for maybe a review on the first and last days of class. Students can lose attention if they don't have to speak up to each other or the professor. Talking to the professor during class can also build their confidence in small ways that are important to their overall development as students and adults.
>
> I think it would be easy for students to fall behind. If I had a particularly busy week, I may not be able to watch the full-30 minute video and would not perform well during class when we are working through problems. I think your video lectures are enough for us to watch at home. It takes me 3-4 hours to fully go through each lecture and take good notes, but I am able to do this when I have some time free on my own schedule (e.g. over the weekend, on Friday nights, etc.)
>
> I think all of the material covered class is important. Even the general chemistry review. I do not think any of it should be removed from the curriculum to be studied on our own. I was forced to select chapter 1 to remove from the list to complete this survey though

I am used to teaching myself difficult topics and using valid resources to research topics that I cannot comprehend using just the class materials. However I strongly believe that some students need the traditional lecturing with plenty of instructor involvement to understand topics. Even if a majority of people find a topic easy there will probably be a group of students that still struggle with it and the in-class lecture would be beneficial to those students. I like the idea of watching the videos before class and discussing them in class, but for an organic chemistry class I do not think it would be beneficial to most students to only cover some topics through online media.

Sampling of responses against changing to a flipped classroom (only edited for typos):

I think watching videos before class would be helpful, then quizzes or some in-class activity, then repetition/reinforcement of concepts in lectures would be beneficial and enable more time for questions

I think the method would improve memory of the material and save class time but would take up more of the students' time. Coupling this with a reduction in online homework may work well to compensate for the additional time requirement placed on the student.

For me sitting for too long without engagement is difficult and the clicker quizzes not only helped me focus my attention but also helped me understand the material.

The hybrid lecture would be very helpful to me. I really benefited from the traditional lecture but would have liked more practice problems or in class quizzes. The flipped classroom is a challenge because it puts so much more responsibility on the student to watch the videos ahead of time. This is not always easy to do with a busy schedule. I like listening to the instructor's interpretation of the textbook in a traditional lecture setting.

It seems like a good idea. Definitely don't make students watch too much on their own because some weeks students have so much that they might not have time to watch it if it's long. Also, I wouldn't make the worksheets worth much. Maybe some count towards points and some be bonus

Overall, the decision whether to flip the organic lecture should not rest solely on the faculty or student opinions but should include those factors along with the relevant chemistry education research, resources available and other factors. Based on the overall increase in student grades and student satisfaction with the incorporation of active learning into the lecture, along with feedback from students and faculty about a hesitancy to move to a flipped classroom, the need to flip the organic lecture is not warranted. A traditional lecture with heavy doses of engagement and active learning and some partially flipped lectures has worked extremely well for organic chemistry at UNO and should continue without changes.

7.8 Impact on Student's Performance from Pedagogical Changes

In addition to student survey, another (more important) measure of pedagogical success is the impact of student performance in the organic lecture with changes in pedagogy. The success of pedagogical changes is summarized in tables 15 and 16. The test averages, final exam averages and overall class averages for organic 1 lectures are summarized in table 15. The test averages, final exam averages and class averages for organic 2 lectures are summarized in table 16. Active learning was introduced in 2011 with individual and group clicker quizzes. More advanced active learning activities, such as peer instruction and PLTL-like questions, were introduced in 2015.

For organic 1, the fall 2008 and fall 2009 cohorts were prior to the incorporation of active learning. For those two cohorts, the test average was 83.4%, the final exam average was 77.1% and the class average was 82.0%. In fall 2010, the author did not teach an organic 1 lecture. The fall 2011 through fall 2014 cohorts were after the introduction of group work and individual/group clicker quizzes. For those four cohorts, the test average was 83.4%, the final exam average was 81.1% and the class average was 83.6%. The fall 2015 and fall 2016 cohorts were after the introduction of more advanced active learning activities. For those two cohorts, the test average was 81.1%, the final exam average was 82.9% and the class average was

87.4%. Overall, the fall 2011 through fall 2016 cohorts (after introduction of active learning) had test averages of 82.6%, final exam averages of 81.7% and class averages of 84.9%.

Comparing test averages only, the cohorts (2) prior to active learning compared to all the cohorts (6) after active learning had a slightly higher test average (83.4% versus 82.6%). The test average for the two cohorts with the most active learning had the "worst" overall average at 81.1%. However, the final exam average improved dramatically over these cohorts. The pre-active learning cohorts final exam average were 77.1%; the post-active learning cohorts final exam average were 81.7%, which is a 6.0% increase. Comparing pre-active learning cohorts (77.1%) to the clicker quiz cohorts (81.1%), results in a 5.2% increase and comparing pre-active learning cohorts (77.1%) to the most advanced active learning cohorts (82.9%), results in a 7.5% increase, which is over a half a letter grade increase.

Comparing final class averages, the pre-active learning cohorts had an 82.0% average. The overall active learning cohorts had an 84.9%. Specifically, the clicker quiz cohorts (fall 2011-fall 2014) had an 83.6% average and the advanced active learning cohorts (fall 2015-fall 2016) had an 87.4% average. Overall, the active learning cohorts had a 3.5% increase in class average. The clicker quiz cohorts had a 2.0% increase in class average and the advanced active learning cohorts had a 6.6% increase in class average.

For organic 1 cohorts, active learning seemed to have little to no effect on individual test averages. But significant effects were seen on the final exam scores and overall class scores. The final exam average increased by 6% from pre-active learning to post-active learning cohorts and by 7.5% from pre-active learning to most advanced active learning cohorts. The class average increased by 3.5% from pre-active learning to post-active learning cohorts and by

6.6% from pre-active learning to most advanced active learning cohorts. Both the final exam averages and the class averages increased by a half a letter grade when comparing pre-active learning to the most active learning cohorts.

Overall, the results suggest that active learning does not help with individual test averages for organic 1 but does help with retention of material for final exam scores and for overall class averages. The sample size for the pre-active learning group is small so this could skew the results. But there is a clear trend that the more active learning in a lecture seems to correspond to an increase in final exam average and overall class average (table 15).

Table 15: Organic 1 Lecture Averages from Fall 2008 to Fall 2016.

Organic 1 Lecture						
Notes	Semester	Students	Test Avg	Final Avg	Class Avg	Notes
Before Active Learning	Fall 2008	67	83.4	75	80	4 tests
	Fall 2009	70	83.3	79.1	83.9	4 tests
	Average		83.4	77.1	82.0	
Introduction of Active Learning (Clicker Quizzes)	Fall 2011	128	83.1	76	80.8	4 tests
	Fall 2012	147	83.1	84.5	84.4	4 tests
	Fall 2013	124	86.7	84	86.1	5 tests + drop
	Fall 2014	74	80.7	80	83.2	5 tests + drop
	Average		83.4	81.1	83.6	
Addition of Peer Instruction…	Fall 2015	71	81.3	81.1	86.8	5 tests + drop
	Fall 2016	73	80.9	84.6	88	5 tests + drop
	Average		81.1	82.9	87.4	
All Active Learning	Average		82.6	81.7	84.9	

For organic 2, the fall spring 2009 and 2010 cohorts were prior to the incorporation of active learning. For those two cohorts, the test average was 83.5%, the final exam average was 79.7% and the class average was 84.4%. The spring 2011 through spring 2014 cohorts (along with summer 2013 and fall 2013) were after the introduction of group work and individual/group clicker quizzes. For those six cohorts, the test average was 86.0%, the final exam average was 86.0% and the class average was 86.6%. The spring 2015 through spring 2017 cohorts were after the introduction of more advanced active learning activities. For those two cohorts, the test average was 85.9%, the final exam average was 88.4% and the class average was 89.5%. Overall, the spring 2011 through spring 2017 cohorts (after introduction of active learning) had test averages of 86.0%, final exam averages of 86.8% and class averages of 87.5%.

Comparing test averages only, the cohorts (9) after active learning compared to the cohorts (2) prior to active learning had a higher test average (86.0% versus 83.5%). Unlike organic 1, an improvement in test average was seen for all active learning cohorts compared to non-active learning cohorts. Overall, the test average increased by 3%. This is not a huge increase but there is an increase, which is encouraging compared to organic 1. However, the final exam average again improved dramatically over these cohorts. The pre-active learning cohorts final exam average were 79.7%; the post-active learning cohorts final exam average were 86.8%, which is an 8.7% increase. Comparing pre-active learning cohorts (79.7%) to the clicker quiz cohorts (86.0%), results in a 7.9% increase (almost ¾ of a letter grade improvement) and comparing pre-active learning cohorts (79.7%) to the most advanced active learning cohorts (88.4%), results in a 10.9% increase, which is almost a full letter grade increase.

Comparing final class averages, the pre-active learning cohorts had an 84.4% average. The overall active learning cohorts had an 87.5%. Specifically, the clicker quiz cohorts had an 86.5% average and the advanced active learning cohorts had an 89.5% average. Overall, the active learning cohorts had a 3.4% increase in class average. The clicker quiz cohorts had a 2.5% increase and the advanced active learning cohorts had a 6.0% increase in class average.

Unlike organic 1 cohorts, the organic 2 active learning cohorts had a small but significant 3% increase in test averages. Again, significant effects were seen on the final exam scores and overall class scores. The final exam average increased by 8.7% from pre-active learning to post-active learning cohorts and by 10.9% from pre-active learning to most advanced active learning cohorts. The class average increased by 3.4% from pre-active learning to post-active learning cohorts and by 6.0% from pre-active learning to most advanced active learning cohorts. The final exam averages increased by a full letter grade and the class averages increased by a half a letter grade when comparing pre-active learning to the most active learning cohorts.

Overall, the results suggest that active learning does help with individual test averages for organic 2 but helps even more with retention of material for final exam scores and for overall class averages. The final exam average showed a full letter grade improvement from pre-active learning to most advanced active learning cohorts. The overall class average increased by half a letter grade from pre-active learning to most advanced active learning cohorts. Again, the sample size for the pre-active learning group is small so this could skew the results. But there is a clear trend that the more active learning in a lecture seems to correspond to a significant increase in final exam average and overall class average for organic 2 chemistry lecture (table 16).

Table 16: Organic 2 Lecture Averages from Fall 2008 to Fall 2016.

Organic 2 Lecture						
Notes	Semester	Students	Test Avg	Final Avg	Class Avg	Notes
Before Active Learning	Spring 2009	71	82.7	77.3	83.7	4 tests
	Spring 2010	100	84.3	82.1	85	4 tests
	Average		83.5	79.7	84.4	
Introduction of Active Learning (Clicker Quizzes)	Spring 2011	85	90.9	86.7	88.9	4 tests
	Spring 2012	153	85.5	91	84.5	4 tests
	Spring 2013	126	86.8	85.3	88.3	4 tests
	Summer 2013	29	85.3	82.8	84.4	4 tests
	Fall 2013	74	84.3	85.8	85.1	5 tests + drop
	Spring 2014	102	83.2	84.6	87.7	5 tests + drop
	Average		86.0	86.0	86.5	
Addition of Peer Instruction…	Spring 2015	92	85.6	94	86.5	5 tests + drop
	Spring 2016	69	85.8	86	90.1	5 tests + drop
	Spring 2017	77	86.2	85.1	91.9	5 tests + drop
	Average		85.9	88.4	89.5	
All Active Learning	Average		86.0	86.8	87.5	

Table 17: Organic 1 and 2 Averages and Standard Deviation

Organic 1 Lecture						
	Test Average	Amount of Deviation	Final Exam Average	Amount of Deviation	Class Average	Amount of Deviation
Before Active Learning	83.4	0.309	77.1	-0.909	82	-0.783
Introduction of Active Learning	83.4	0.309	81.1	0.160	83.6	-0.214
Addition of Peer Instruction	81.1	-0.876	82.9	0.642	87.4	1.14
Average for All	82.8		80.5		84.2	
Standard Deviation	1.94		3.74		2.81	

Organic 2 Lecture						
	Test Average	Amount of Deviation	Final Exam Average	Amount of Deviation	Class Average	Amount of Deviation
Before Active Learning	83.5	-0.917	79.7	-1.327	84.4	-0.936
Introduction of Active Learning	86.0	0.229	86.0	0.114	86.5	-0.150
Addition of Peer Instruction	85.9	0.183	88.4	0.664	89.5	0.974
Average for All	85.5		85.5		86.9	
Standard Deviation	2.18		4.37		2.67	

The results of the almost eight years of organic chemistry students at UNO suggest that adding active learning to the lecture increased retention of material in the students based on the improvement of final exam scores. The data suggests that there is not a huge increase on individual test scores (especially in organic 1) but a strong trend towards increased overall class averages. Additionally, the data suggests that more advanced active learning (peer lectures, PLTL…) improves grades more than generalized group practice and clicker quizzes. Although the results of the active learning incorporation in organic chemistry are very promising and encouraging there is other future work that should be considered.

One study that would help provide clarity would be to compare the individual population of each cohort (such as GPA, ACT scores) versus their score to normalize the data from cohort to cohort. Also, a comparison of each cohort via a standardized pretest and posttest could also be done; however, UNO does not use the ACS exams institute's organic chemistry final exam, so incorporation of this might not be as easily accomplished as it would a school that uses the ACS exam institute exam for their final exam. Another study would be to have two cohorts in the same semester taught by the same faculty with everything identical except that one cohort would use a traditional lecture and the other cohort would use a hybrid of lecture and active learning. Also, a study could be conducted with two cohorts in the same semester. One would use group exercises/clicker quizzes and the other would use advanced active learning exercises. Another future study would be for a faculty that does not use active learning in organic chemistry to start using active learning and compare the results of that cohort versus their previous non-active learning cohorts. The author should also teach a semester not using any active learning and see if the improvements noted over time from fall

2009 to spring 2017 were based solely on incorporation of active learning or did the faculty improvement in teaching over that time period lead to some (or all) of the increased performance by the students.

Until some (or all) of these studies are done, the improvement of student’s performance (and of student’s satisfaction) from 2009 to spring 2017 can be said fairly convincingly to be at least partially due to the of the incorporation of active learning. However, the improvement of student scores cannot be conclusively said to be entirely due or even mostly due to the incorporation of active learning. It is definitely a factor; but is it the only factor or is it one of many. If it is one of many, is it the main factor or just a contributing factor?

Chapter 8 Concluding Remarks

Chemical education research (CER) has been a huge part of the ACS dating back to the early 1900s. With recruitment and especially retention of students in the STEM fields being so important for departments, colleges and universities across the United States, CER has become a vital part of chemistry departments across the country. The author has seen examples of this first hand when visiting campuses across the country this past year. From small liberal art HBCU, to prestigious private schools, urban PhD granting universities to the university with the biggest student population in the US, every school has hired or is in the process of hiring lecturer positions that focus on CER. While CER will not pull the funding or prestige of primary research conducted at universities, CER will help keep students in the departments and make sure they matriculate in a timely fashion.

The research presented in this dissertation covers multiple parts of CER research, from curriculum development to pedagogical changes to basic scientific communication. All three of these work together to create more compelling, engaging and ultimately successful chemistry courses. Some of the research presented here is a continuation of CER done at multiple universities, while other parts of the research are more cutting edge and unique.

The introduction of recitations at UNO is far from unique and builds on a long and well documented history of successful recitations at larger universities and other regions in the US. The creation of the undergraduate teaching internship is not unique but has much less research than recitations and has potential for future research studies, especially on the effect of the tutors knowledge and retention of material in their upper level classes. The creation of non-science majors chemistry class is not new, but the chemistry of movies and TV course at UNO is unique. Many universities have nonscience majors courses that might have a chapter or two dedicated to this topic, but no course (that has been found) devotes the entire course to the chemistry of movies and TV. The chemistry of our daily lives course is not unique but most of the other courses are still based on a water-downed general chemistry course and not driven by the topics instead of the chemistry.

The VILS (video intensive lecture style) seems to be a unique concept. There are many articles on the limited use of videos in chemistry courses, but no literature can be found on the extensive use of video as the main lecture material. VILS pedagogy, basing a course on real-world topics rather than on a standardized chemistry curriculum and the overall pedagogical approach of using the movie/TV/real world example to explain the chemistry instead of having a chemistry concept and then finding a real world example are all unique features of CHEM 1001 and CHEM 1002.

The individual pedagogical changes used in organic chemistry lectures are well documented in the literature. The author was one of the first faculty to use video recording of lectures in organic chemistry and one of the first (if not the first) to post real-time organic lectures to iTunes U. Some faculty had recorded one off lectures or recorded one semester of lectures and uploaded them but never uploaded new lectures every semester. Many faculty also have studied the use of active learning from clickers to PLTL to POGIL to peer instruction and beyond in organic chemistry lectures. But there is not a lot of primary research comparing the intensity of active learning pedagogy to student improvements and achievements. There is also not a lot of research comparing various pedagogical changes (video recording, online homework, active learning…) to see which is most helpful or perceived that way to students.

Most studies just change one thing, which is easiest for comparing results. But students are not a one size fits all. Many students cannot succeed without video lectures, while other students do not utilize them at all. A definitive study of which methods help which students and trying to identify the student types that are most helped with each pedagogical change has not been carried out and is a missing part of CER.

Overall, some of the work done here is repetitive of work done elsewhere. But a substantial part of this work is unique and has great benefit to the CER community. The author has shared much of this work at conferences, symposia, workshops and so forth. But the author has not shared enough of this work through refereed journals as he should have or would have liked to share. Some of this is due to the fact that much of the work was done not with the aim of getting a PhD but was done solely to improve student outcomes. The next step should be to determine which of this work still has the immediacy to be submitted to journals and submit that work for peer review.

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47. Data from the University of New Orleans Department of Data Management is not available at this time to show exact enrollment figures for the biology courses, http://new.uno.edu/oier/.
48. University of New Orleans catalog, Course of Instructions page, http://www.uno.edu/registrar/catalog/1819catalog/courses-of-instruction/ (accessed March 8, 2019)
49. *Breaking Bad;* TV Show, AMC, 2008-2013.
50. *Game of Thrones;* TV Show, HBO, 2011-2019
51. *Star Trek;* TV Show, TV Show, NBC, 1966-1969
52. *Doctor Who;* TV Show, BBC, 1963-1989; 2005-2019
53. Wells, H.G. *The Invisible Man,* Pearson Publishing: London, UK, 1897
54. Stevenson, R.L. *The Strange Case of Dr. Jekyll and Mr. Hyde*, Longmans, Greene and Co: London, UK, 1886
55. Shelly, M. *Frankenstein: or, The Modern Prometheus*, Lackington, Hughes, Harding, Mavor & Jones: London, UK, 1818
56. *Jurassic Park;* Universal Pictures: Hollywood, CA, 1993
57. *Jurassic World;* Universal Pictures: Hollywood, CA, 2015
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62. Griep M.; Mikasen, M. Based on a True Story: Using Movies as Source Material for General Chemistry Reports *J. Chem. Educ.* **2005**, 82, 1501
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68. TopHat interactive platform, https://tophat.com (accessed March 8, 2019)
69. The textbooks will be available on TopHat but are still being finished so are not yet available on the TopHat marketplace https://tophat.com/marketplace/. For a list of topics and lesson plans, student notes, instructor notes, list of videos, early access to the textbooks or any other inquiry about the Chemistry of Movies and TV course or Chemistry of our Daily Lives, please contact Sean Hickey at either seanhickey@aol.com or sphickey@uno.edu.
70. Most memes either do not have a copyright or use one of the many open content licenses. Where possible, credit is given. Most memes were only used in student notes and not in textbook to avoid a copyright issue.
71. While there are a few research article or books that talk about generation Z students the amount of peer reviewed material is small compared to the research available on millennials. A couple of examples of research include: (a) Turner, A. Generation Z: Technology and Social Interest *J. Individual Psychology*, **2015**, *71*, 103-113 (b) Seemiller, C.; Grace, M. *Generation Z goes to college* Wiley Publishing: Hoboken, NJ 2016
72. Publishers, such as Pearson and Wiley, have invested some time and effort into the research (non peer-reviewed) of generation Z students since those students are the target buying audience for those publishers for the next 10 or more years. Pearson maintains a blog of these articles at https://www.pearsonedc.com/blog-archive/highereducation (accessed March 8, 2019)
73. *The Hobbit: The Desolation of Smaug*; Warner Brothers Pictures: Burbank, CA 2013
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80. *Spectre*; Sony Pictures: Culver City, CA 2015
81. *WKRP in Cincinnati;* TV Show, TV Show, CBS, 1978-1982
82. *Terminator 2: Judgement Day;* Tri-Star Pictures: Culver City, CA 1991
83. *The Abyss*; 20th Century Fox Pictures: Los Angeles, CA 1989
84. *Deep Impact*; Paramount Pictures: Hollywood, CA 1998
85. *Awakenings*; Columbia Pictures: Culver City, CA 1990
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87. *Avatar;* 20th Century Fox Pictures: Los Angeles, CA 2009
88. *The Rock;* Buena Vista Pictures: Burbank, CA, 1996
89. *Pulp Fiction;* Miramax Films: Los Angeles, CA 1994

90. *Awakenings*; Columbia Pictures: Culver City, CA 1990
91. *Star Trek: The Next Generation;* TV Show, CBS, 1987-1994
92. *Futurama;* TV Show, Fox and Comedy Central, 1999-2003 and 2008-2013
93. *Rick and Morty;* TV Show, Adult Swim, 2013-2019
94. *Wonder Woman;* Warner Brothers Pictures: Burbank, CA 2017
95. Hill, J.W.; McCreary, T.W. *Chemistry for Changing Time, 14th edition*; Pearson, London, UK, 2016.
96. Waldron, K. *21st Century Chemistry, 1st edition*; Macmillan; London, UK, 2015.
97. Heller, D.P.; Snyder, C.H. *Visualizing Everyday Chemistry, 1st edition*; Wiley, Hoboken, NJ, 2015.
98. American Chemical Society *Chemistry in Context: Applying Chemistry to Society, 9th edition*; McGraw Hill, New York, NY, 2017.
99. Chemistry is often referred to as the central science because it is a connecting point for math and physics to the life sciences. Chemistry sits in the center of all sciences and connects them together.
100. One definition of chemistry is the study of matter and how matter changes. Matter is anything that has mass and takes up space by having volume. In essence, chemistry is the study of everything (except for pure energy) and how everything changes.
101. Adams, D. *Life, the Universe and Everything*; Pan Books, UK, 1982.
102. Adams, D. *The Hitchhiker's Guide to the Galaxy*; Pan Books, UK, 1979.
103. I conducted a survey separate from UNO's course evaluations using Qualtrics. My survey asked about specific topics, videos and other parts of the course. The overall feedback was more videos, especially unique videos that connected chemistry to media.
104. UNO's course evaluations were very good for the course, averaging a 4.69/5.00. In the comments section, the negative comments usually focused on too much "lecturing" not enough videos.
105. SciShow's YouTube channel, https://www.youtube.com/channel/UCZYTClx2T1of7BRZ86-8fow (accessed March 8, 2019)
106. It's Okay to be Smart's YouTube channel, https://www.youtube.com/channel/UCH4BNI0-FOK2dMXoFtViWHw (accessed March 8, 2019)
107. AsapSCIENCE's YouTube channel, https://www.youtube.com/channel/UCC552Sd-3nyi_tk2BudLUzA (accessed March 8, 2019)
108. Last Week Tonight with John Oliver's YouTube channel, https://www.youtube.com/user/LastWeekTonight (accessed March 8, 2019)
109. Andy Brunning's CompoundChem site is a great source for chemistry infographics. He has an index, so you can look up by topic. I contacted Andy and as long as you are using for educational purposed with no monetization, you can use his infographics.
110. Compound Chem site, https://www.compoundchem.com (accessed March 8, 2019)
111. *In Living Color;* TV Show, Fox, 1990-1994
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113. *Seinfeld*; TV Show, NBC, 1989-1998
114. Science and Entertainment consulting group, http://scienceandentertainmentexchange.org (accessed March 8, 2019)
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118. YouTube's fair use policy, https://www.youtube.com/yt/about/copyright/fair-use/#yt-copyright-protection (accessed March 8, 2019)
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120. This is a paraphrase of how I started this lecture for the first two semesters I taught the course.
121. Stains, M. et al Anatomy of STEM Teaching in North American Universities *Science*, **2018**, *359*, 1468-1470
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127. Bunce D; Flens, E.; Neiles K. How Long Can Students Pay Attention in Class? A Study of Student Attention Decline Using Clickers *J. Chem. Educ.*, **2010**, *87*, 1438-1443
128. A search of ACS publications on January 7, 2019 brought up four journal articles, one C&EN article and one book chapter. All published in 2017 and 2018. Only 2 of which involve the Game of Thrones TV show and do not impart any useful research.
129. Most of the citations used were from entertainment sites (variety.com, ew.com, i09.com) or aggregating sites (Wikipedia.com, gameofthrones.wikia.com). I would most often have to find the science and then make sure that my analysis was correct using textbooks and articles.
130. Keen, H. *The Science of Game of Thrones;* Little, Brown and Company: Columbus, GA, 2016
131. What is a trope? https://tvtropes.org/pmwiki/pmwiki.php/Main/Tropes (accessed March 8, 2019)
132. Shot to heart trope. https://tvtropes.org/pmwiki/pmwiki.php/Main/ShotToTheHeart (accessed March 8, 2019)

133. Puntambekar, S.; Kolodner, J. L. Toward Implementing Distributed Scaffolding: Helping Students Learn Science from Design *J. Res. Sci. Teach.,* **2005**, *42*, 185– 217
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135. For the fire-breathing POD, I use videos from *The Hobbit*, Periodic Video on hypergolic liquids, multiple YouTube videos on bombardier beetles and clips from *Starship Trooper.*
136. This is a paraphrase of how I started this lecture for the first two semesters I taught the course.
137. Champoux, J.E. Film as a Teaching Resource *Journal of Management Inquiry*, **1999**, *8*, 206–217
138. Bluestone, C. Feature Films as a Teaching Tool *College Teaching,* **2000**, *48*, 141-146
139. Masters, J.C. Hollywood in the Classroom: Using Feature Films to Teach *Nurse Educator*, **2005**, *30*, 113-116
140. Salomon, G. *Interaction of media, cognition, and learning: An exploration of how symbolic forms cultivate mental skills and affect knowledge acquisition.* Jossey-Bass: San Francisco, 1979.
141. Cowen, P. S. Film and text: Order effects in recall and social inferences *Educational Communication and Technology*, **1984**, *32*, 131-144.
142. Bransford, John; Brown, Ann; Cocking, Rodney. *How People Learn - Brain, Mind, Experience, and School.* National Academy Press: Washington, DC., 1999.
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144. Video surveys were conducted on many of the videos used in the class. The results were very similar as long as the video had some sort of science in it or right after the video, I explained the science. Surveys were done on paper in 2015 and 2016, by iClicker in 2017 and TopHat in 2018.
145. Pew Research Center Poll on Major Gap Between the Public, Scientists on Key Issues, http://www.pewinternet.org/interactives/public-scientists-opinion-gap/ (accessed March 8, 2019)
146. NASA, Climate Change, https://climate.nasa.gov/vital-signs/global-temperature/ (accessed March 8, 2019)
147. NASA, Goddard Institute for Space Studies, https://data.giss.nasa.gov/gistemp/ (accessed March 8, 2019)
148. It's Okay to be Smart, What you need to know about climate change?, https://www.youtube.com/watch?v=ffjIyms1BX4 (accessed March 8, 2019)
149. It's Okay to be Smart, What's REALLY Warming the Earth?, https://www.youtube.com/watch?v=hphdsLcSTYQ (accessed March 8, 2019)
150. Kurzgesagt, How do Greenhouse Gases Actually Work?, https://www.youtube.com/watch?v=sTvqIijqvTg (accessed March 8, 2019)
151. *Napoleon Dynamite,* MTV Films: Hollywood, CA, 2004

152. Article on feeding onions to cows to affect climate change, https://gizmodo.com/scientists-feed-cows-onions-to-make-them-stop-farting-s-1791347637 (accessed March 8, 2019)
153. Yale Climate Connections, Merchants of Doubt: What Climate Deniers Learned from Big Tobacco, https://www.youtube.com/watch?v=cJIW5yVk__w&t=7s (accessed March 8, 2019)
154. Merchants of Doubt, Participant Media: Los Angeles, CA, 2014
155. Last Week Tonight, TV Show, HBO, 2014-Present, John Oliver is one of the most if not the most pro-science media member.
156. Last Week Tonight with John Oliver, Climate Change Debate, https://www.youtube.com/watch?v=cjuGCJJUGsg (accessed March 8, 2019)
157. It's Okay to be Smart, Why Don't People Believe in Climate Change, https://www.youtube.com/watch?v=y2euBvdP28c&t=88s (accessed March 8, 2019)
158. I conducted a survey separate from UNO's course evaluations using Qualtrics. My survey asked about specific topics, videos, and other parts of the course. The overall feedback was in favor of more videos, especially unique videos that connected chemistry to media.
159. UNO's course evaluations were very good for the course, averaging a 4.69/5.00. In the comments section, the negative comments usually focused on too much "lecturing" and not enough videos.
160. CHEM 1001 and 1002's YouTube channel. https://www.youtube.com/channel/UC1WVjpGmMynNelUqjabKJtA?view_as=subscriber (accessed March 8, 2019).
161. Solomons, G.; Fryhle, C.; Snyder, S Organic Chemistry, 12th edition. Wiley: Hoboken, NJ, 2018
162. ChemAxon Homepage, https://chemaxon.com/products/marvin (accessed June 9, 2019).
163. Reaction Explorer homepage, http://www.reactionexplorer.com (accessed June 9, 2019).
164. Chen, J. H.; Kayala, M. A.; Baldi, P. Reaction Explorer: Towards a Knowledge Map of Organic Chemistry to Support Dynamic Assessment and Personalized Instruction in *Enhancing Learning with Online Resources, Social Networking, and Digital Libraries*, American Chemical Society, Washington, D.C. p. 191-209, (2010)
165. Chen, J. H.; Baldi, P. No Electron Left-Behind: A Rule-Based Expert System to Predict Chemical Reactions and Reaction Mechanisms *Journal of Chemical Information and Modeling,* **2009,** *49*, 2034-2043.
166. Chen, J. H.; Baldi, P. Synthesis Explorer: A Chemical Reaction Tutorial System for Organic Synthesis Design and Mechanism Prediction *J. Chem. Educ.*, **2008**, *81*, 1699.
167. ORION homepage and whitepapers, http://www.wileydigitalsolutions.com.au/orion/ (accessed June 9, 2019).
168. Shinywhitebox homepage, https://shinywhitebox.com (accessed June 10, 2019).
169. iTunes U faculty homepage, https://itunesu.itunes.apple.com (accessed June 10, 2019).

170. Organic 1 homepage on iTunes U, https://itunes.apple.com/us/course/organic-chemistry-1-lecture/id561733804 (accessed June 10, 2019).
171. Organic 2 homepage on iTunes U, https://itunes.apple.com/us/course/organic-chemistry-2-/id561733766 (accessed June 10, 2019).
172. Telestream homepage, https://www.telestream.net/screenflow/overview.htm (accessed June 10, 2019).
173. LSU Center for Academic success homepage, https://www.lsu.edu/cas/earnbettergrades/vlc/CAS_VLC_StudyCycleFSS.pdf (accessed June 13, 2019).
174. Christ, F.L. *Seven steps to better management of your study time.* H&H Publishing: Clearwater, FL, 1997.
175. McGuire, S.Y.; McGuire, S. *Teach Students How to Learn: Strategies You Can Incorporate in Any Course to Improve Student Metacognition, Study Skills, and Motivation.* Stylus Publishing, Sterling, VA, 2016.
176. Klein, D. Organic Chemistry, 3rd edition. Wiley: Hoboken, NJ, 2017.

Appendix 1 Documents for Curriculum Changes

1.1 Proposal for CHEM 3092

THE UNIVERSITY of NEW ORLEANS

REQUEST TO ADD, DROP, OR CHANGE A COURSE[1]

Departmental Prefix: CHEM New Course No. (if applicable) 3092 Cr. Hrs. 2 CIP:
Add "G" No. (if applicable) ______ Cr. Hrs. ______ (For Academic Affairs)

X **ADD A COURSE** (Please proceed to page 4.)
Course Title: **Undergraduate Teaching Apprenticeship**

☐ **DROP A COURSE** (Please proceed to page 8.)

☐ **CHANGE A COURSE** (Check all that apply, then proceed to page 9.)

☐ Course Title
From:
To:

☐ Prerequisite/Description

☐ Credit Hours
From: credit hours
To: credit hours

☐ Course Number (include department prefix/course number)
From: Existing course number — Insert "G" number (if applicable)
To: New course number[2] — Insert "G" number (if applicable)

☐ Other (Please indicate below)

☐ Non-substantive Use this page for signatures only. Please describe requested change(s) in the box provided on page 3.

Semester/Year for which change is requested: **Fall 2013** Approved effective date:
(To be completed by Academic Affairs)

Recommended abbreviation for class schedule (include spaces, **ONE LETTER** per box)

U	N	D	E	R	G	R	D		T	E	A	C	H		A	P	P	R	

[1] Effective as of February, 2009.
[2] You may **NOT** use a course number that has been used previously with the exception of a course number for a one-time waiver that is more than five years old.

For a request to drop or change, where is the most recent description (current .pdf catalog version)?

Page

List all courses and curricula affected by this request. Submit request for other changes **concurrent** with this request.

Bachelor of Science in Chemistry ______

______ ______

Other departments or units affected by this action. Supply additional information, if needed, on a separate sheet.

		☐	☐
		☐	☐
		☐	☐
		☐	☐
		☐	☐
		☐	☐

Department or unit   Chair or unit head signature (plus date)   Support   Not Support

---

Signatures constitute approval. Signatures by the department chair and the courses and curricula committee chairs certify that the proposal was discussed and approved by a majority of the voting members of the department or committee.

______ ______ ______ ______

Department Chair   Date   Campus Courses and Curricula Chair   Date

______ ______ ______ ______

College Courses and Curricula Chair   Date   Graduate Dean   Date

(Courses numbered 4000-7999)

______ ______ ______ ______

College Dean   Date   Provost   Date

Please proceed to the section below that applies to the action that you are requesting, and provide the appropriate information.

Be sure to describe additional work for graduate credit, if applicable.

Adding a New Course

Course description for a new course

(Please insert **course number** ["xxxx/xxxxG" if appropriate] and **title**, **credit hours**, and **catalog description** in the designated spaces below. You may **NOT** use a course number that has been used previously with the exception of a number for a one-time waiver that is more than five years old.)

CHEM 3092 Undergraduate Teaching Apprenticeship 2 cr.

Prerequisite: Consent of department. Students will spend a semester training and shadowing with an experienced TA. The training will consist of learning the chemistry involved in the teaching labs, along with safety and practical knowledge to teach either CHEM 1007 1008, 2017 or 2018. Student will shadow a TA for at least one section of their target lab. Student will spend another 3 hours per week in various activities that include a weekly meeting with all TA and instructors, and 1-2 hours work in the tutoring center. May be used for university general elective credit. May be taken up to 3 times for a maximum of 6 credit hours.

Please note: if there is a "G" number and the course description is the same for both courses, simply append the "G" number to the other course number, as illustrated above. If the "G" number has a different description, please use a separate form.

Justification and explanation for a proposed course, including information about:

- **Why the course is needed**
- **How often the course will be offered**
- **Any enrollment or curriculum restrictions**
- **Anticipated enrollments**
- **Any additional personnel, equipment, or facilities required (if none, indicate 'No additional personnel, equipment, or facilities will be needed.')**

As part of the department's retention and recruitment initiatives, we initiated an undergraduate TA program in the summer of 2012. We had two students complete the program last summer and have been teaching their own labs these past two semesters. In Fall 2012, we had over 10 students go through training. This term there are over 15 students involved in the training. The program has great benefits for both the students and the department. Students get a chance to hone their general chemistry and organic chemistry skills while also learning practical skills such as leadership, oral communication, organizational skills, personal responsibility amongst others. The main advantage for the department (and college and university) is that the more invested students are in the department and the college, the more likely they are to be retained semester to semester. The course will be offered every academic semester.

There are no prerequisites for the course other than department approval of the teaching assistantship. Based on previous semesters interest in this program, we expect 3-10 students per semester.

No additional personnel, equipment, or facilities will be needed.

1.2 Syllabus and Contract for CHEM 3092

Chemistry 3092, Teaching Apprenticeship

Instructor:	Sean Hickey
Office:	CSB 112
Office Hours:	TTH 4-530 pm
Tel.:	280-1273
E-mail:	sphickey@uno.edu
Prerequisite:	Consent of department
Description:	Students will spend a semester training and shadowing with an experienced TA. The training will consist of learning the chemistry involved in the teaching labs, along with safety and practical knowledge to teach either CHEM 1007 1008, 2017 or 2018. Student will shadow a TA for at least one section of their target lab. Student will spend another 3 hours per week in various activities that include a weekly meeting with all TA and instructors, and 1-2 hours work in the tutoring center. May be used for university general elective credit. May be taken up to 3 times for a maximum of 6 credit hours.
Credit:	2 credit hours
Text:	Text and other resources will be specified in the Course Contract

Student Learning Objectives

Students who complete this course should have a sufficient understanding of the material and experience to be an Undergraduate Teaching Assistant in their targeted lab in subsequent semesters after their training.

Attendance Policy
Regular attendance is required.

Exam Schedule
There will be no tests or exams associated with this apprenticeship.

Grading
Course grade will be based on student performance and mastery of the topic material. Attendance and appropriate time commitment to the course will be included in grading. Detailed grading procedures will be specified in the Course Contract

Accommodations
It is University policy to provide, on a flexible and individualized basis, reasonable

accommodations to students who have disabilities that may affect their ability to participate in course activities or to meet course requirements. Students with disabilities should contact the Office of Disability Services as well as their instructors to discuss their individual needs for accommodations. For more information, please go to http://www.ods.uno.edu.

Classroom Conduct

Cell phones should be turned OFF before entering class. Chronic tardiness will be penalized.

Additional Resources

Specific resources will vary for this course and will be noted in the Course Contract. General resources are noted below.

SciFinder (scientific literature database available in UNO library)

American Chemical Society Journals (available in UNO library or online through UNO connection at www.acs.org)

Academic Integrity

Academic integrity is fundamental to the process of learning and evaluating academic performance. Academic dishonesty will not be tolerated. Academic dishonesty includes, but is not limited to, the following: cheating, plagiarism, tampering with academic records and examinations, falsifying identity, and being an accessory to acts of academic dishonesty. Refer to the Student Code of Conduct for further information. The Code is available online at http://www.studentaffairs.uno.edu.

Plagiarism is a serious offense that can result in failure in a course and dismissal from the university.[3] Students must make special efforts to learn what constitutes plagiarism and how to properly utilize and cite the work of others.

"Plagiarize 1. To steal and use (the ideas or writings of another) as one's own. 2. To appropriate passages or ideas from (another) and use them as one's own . . . To take and use as one's own the writings or ideas of another." - definition from *The American Heritage Dictionary of the English Language*, W. Morris, Ed. American Heritage Publishing Company, Inc. and Houghton Mifflin Company: New York, 1969.

Verbatim, or word for word copying, is the most obvious form of plagiarism. However, substantially copying the ideas or presentation of another, even when wording has been changed, can also constitute plagiarism.

The final exam will be evaluated using turnitin via Moodle. A similarity score of less than 15% is required. A submitted report with a similarity score higher than 15% will be further investigated to determine if plagiarism is involved. Up until the deadline of noon on Dec 8, the

[3]International students who are dismissed from the university can lose their visa status, requiring them to return to their home country.

exam can be revised to decrease the similarity score. Papers will also be manually assessed for plagiarism.

Free Tutoring Available On-Campus from the UNO Learning Resource Center:
http://www.uno.edu/lrc/
Free Chemistry Tutoring Available in the Chemistry Learning Center - CSB 101

Chemistry 3092 Course Contract

Credit Hours: 2

Year:	2015	Semester:	Fall
Student Name:	XXXXXXXXXXXXX	UNO ID:	XXXXXXX
Faculty Supervisor:	Sean Hickey		
Project Title:	Undergraduate Lab TA		

Student Learning Objectives:

Student will learn the proper procedures, techniques, chemistry and safety for running undergraduate general chemistry or organic chemistry lab. Fundamentals of chemistry and how they relate to laboratory techniques and experiments will be of utmost importance. Additionally, supervisory and management skills will be learned in the process of this course.

Description of work to be completed by student:

Student will follow an experienced TA during the weekly lab meetings. Student will also attend a weekly staff meeting for the lab and conduct tutoring hours in the tutoring center. Student will assist during the lab, and as the semester proceeds he/she may be asked to lead a lab later in the term.

Description of deliverables:

Student will complete a survey describing his/her experience and learning.

Description of supervision (e.g. how often will student meet with supervisor, etc.):

Student will meet weekly with supervisor during weekly staff meeting and will be observed weekly in the lab.

Evaluation and grading criteria:

Grade will be based on performance in the lab and completion of the survey.

Acceptance of Course Contract:

____________________________	_________	____________________________	_________
Student Signature	Date	Faculty Supervisor Signature	Date

1.3 Example of UTA Created Lesson for CHEM 3092

Lewis Structures

I would start by writing the steps on the board and reading them out loud to the class, and then work an example stopping at each step to read it and make sure that it is followed.

Step 1: Sum the valence electrons.
Step 2: Pick a central atom (typically the most electro negative).
Step 3: Draw single bonds from the central atom to each exterior atom.
Step 4: Complete the octet exterior atoms (fill the most electro negative exterior atoms first).
Step 5: Place remaining electrons on central atom.
Step 6: If the octet of the central atom is not filled, move electron pairs from exterior atoms to form double and triple bonds.
Step 7: Check for resonance structures.
Step 8: If the compound is an ion/has a charge, put brackets around the structure.
Step 9: Check your work by counting the number the electrons in your structure (single lines are 2 electron, double lines are 4 electrons and so on).

<<<<<Things to be aware of>>>>>
Summing up the valence e^- improperly.
Drawing double and triple bonds prior to adding lone pairs to the central atom.
Violating the octet rule for any of the atoms that aren't exceptions.
Exceptions to the octet rule Boron (is satisfied with 3 bonds), the other main exceptions are all from the 3rd period of the periodic table i.e. sulfur, and phosphorus.
If the compound has an overall **NEGATIVE** charge it will be **ADDING** electrons; whereas, if it has an overall **POSITIVE** charge it will be **REMOVING** electrons.

Example:
O_3 (picked because it has resonance and a lone pair).

Step 1: Sum the valence electrons.
Oxygen has 6 valence electrons so (6x3)=18e^-

Step 2: Pick a central atom (typically the most electro negative).
Since O is the only atom, it has to be the central atom.

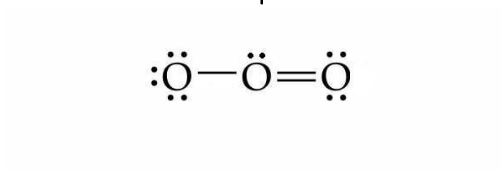
Step 3: Draw single bonds from the central atom to each exterior atom.

Step 4: Complete the octet exterior atoms (fill the most electro negative exterior atoms first).

(I was not able to make a picture in word of this step)

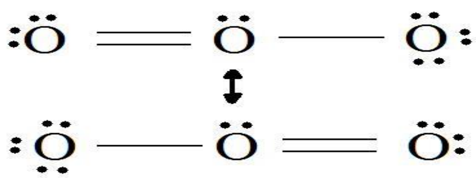
Step 5: Place remaining electrons on central atom.
(I was not able to make a picture in word of this step)

Step 6: If the octet of the central atom is not filled, move electron pairs from exterior atoms to form double and triple bonds.



I found this image on from a Google search.

Step 7: Check for resonance structures.



I found this image on from a Google search.

Step 8: If the compound is an ion/has a charge, put brackets around the structure.
Total charge is neutral, but the exterior oxygen that is single bonded has a -1 formal charge that can be written, and the central oxygen has a +1 charge. I don't think this was required for 1018 though.

Step 9: Check your work by counting the number the electrons in your structure (single lines are 2 electron, double lines are 4 electrons and so on).

Example for an expanded octet would be ClF_3
Example for a molecule with a charge would be CO_3^{2-} or NH_4^+

1.4 Example of UTA Evaluation of Literature

Example Article Review from UTA, #1:

The PLTL program offers students a more interactive learning approach by pairing them in study groups lead by peers. The goals of this new learning method were to improve the student's problem-solving skills, help the students become more interested in the material they are learning, provide the extra help they might need, and to teach them how to effective work in a group study with other students. The overall intention of the PLTL workshop was to simply improve the student's scores by providing them with the extra help they might need. These PLTL groups originally began as an optional course that was available to all students. The only requirements to enrolling in this course were that once a student joined the PLTL study, they had to sign a contract agreeing full participation and a perfect attendance. Once these students completed the course with a perfect attendance and also receiving an "A" letter grade for their first semester of General Chemistry, they were then invited to apply to become a peer leader .The peer leaders were then guided by the group leaders during the classes to work problems within the groups. Role-playing gave peer leaders insight on what is was like to be an actual leader, by giving the peer leaders turns to explain a few problems. Not only was this practice with explaining problems to students, but it also gave peer leaders a chance on how to react to difficult problems. When the class was over, the peer leader would then write a short overview about the material explained that day and any helpful teaching methods observed from the group leaders. The idea was to help these new peer leaders develop the best way to teach these materials to their future students. The results from these PLTL workshops proved successful. It was concluded from the data taken over the years that students who participated in the PLTL groups performed about one-third of a grade point higher than students who did not participate in these groups for the General Chemistry course. The results also displayed a higher increase in retention rate for the students who participated in the PLTL workshops versus the students who did not. Another bonus was that these results revealed that the students who participated in the PLTL groups had a positive attitude towards them.

Interesting Notes: More females than males joined the PLTL to become peer leaders. The average span of peer leader is 3 semesters, 1% serving the maximum six semesters, and 3% being asked to resign because of poor attendance. Females were more intimidated to participate in groups than males, though there were significantly more females than males in the PLTL program. One of the most common responses from females students were that they felt they understood the concept better if they could see a picture, while male students seemed more positive about problem solving and explaining problems to others. The survey results that overall students felts positive towards about PLTL included: The PLTL's effect on study skills and performance, the group dynamics, the student's assessment of his or her ability in chemistry, and lastly the student's perceptions of study groups.

Example Article Review from UTA, #2:

Peer Led Team Learning

The article discusses a study that was done on the PLTL by Washington University at St. Louis. The goals of the Peer sessions were to teach students how to effectively use group study, improve problem-solving skills, and provide help for students in an active learning environment. The course was optional to students, but if a student enrolled attendance was mandatory.

The study observed the students success in class, and their overall attitude about the course which included things like their confidence levels. In general the results showed that students who were in the PLTL performed better in the class, and they were also less likely to drop the course. The students who participated in PLTL almost had a full letter grade higher final average than those who did not.

Example Article Review from UTA, #3:

Peer-Led Team Learning

Peer-Led Team Learning (PLTL) helps students understand the concept of General Chemistries. UNO has recitations that meet up with students every week to assimilate with the course. The students who pay attention in class and recitation have a higher retention rate rather than students that do not. Being a teaching assistant isn't the only activity that helps increase student's knowledge about general chemistries, but also the tutoring session UNO employs. UNO tutoring for chemistry allows students, who are having a difficult time understanding the material, to receive help.

PLTL applies to UNO in many ways. Being a teaching assistant strengthens communication and leadership skills. It also helps the TA by having the subject kept fresh in his/her brain for future applications, for example the MCAT. Not everyone learns the same way a professor teaches, so students tend to teach the lesson their way (which might be more understandable); and this basically clicks like a light switch in their brain.

The PLTL organization helps the students meet other students within the course. Because of this, the students would have study groups within their own timeframe and study the material. In conclusion, PLTL study shows that students who participate more tend to increase their grade by a third of a point (B to B+).

1.5 Proposal for CHEM 3091

REQUEST TO ADD, DROP, OR CHANGE A COURSE[4]

Departmental Prefix: **CHEM** New Course No. (if applicable) **3091** Cr. Hrs. **1-3**

CIP: _____

Add "G" No. (if applicable) _____ Cr. Hrs. _____

(For Academic Affairs)

X **ADD A COURSE** (Please proceed to page 4.)

Course Title: **Chemistry Internship**

☐ **DROP A COURSE** (Please proceed to page 8.)

☐ **CHANGE A COURSE** (Check all that apply, then proceed to page 9.)

- ☐ Course Title
  - From:
  - To:
- ☐ Prerequisite/Description
- ☐ Credit Hours
  - From: credit hours
  - To: credit hours
- ☐ Course Number (include department prefix/course number)
  - From: Existing course number — Insert "G" number (if applicable)
  - To: New course number[5] — Insert "G" number (if applicable)
- ☐ Other (Please indicate below)
- ☐ Non-substantive Use this page for signatures only. Please describe requested change(s) in the box provided on page 3.

Semester/Year for which change is requested: **Fall 2013** Approved effective date: **(To be completed by Academic Affairs)**

Recommended abbreviation for class schedule (include spaces, **ONE LETTER** per box)

C	H	E	M	I	S	T	R	Y		I	N	T	E	R	N	S	H	I	P

[4] Effective as of February, 2009.

[5] You may **NOT** use a course number that has been used previously with the exception of a course number for a one-time waiver that is more than five years old.

For a request to drop or change, where is the most recent description (current .pdf catalog version)?

Page

List all courses and curricula affected by this request. Submit request for other changes **concurrent** with this request.

Bachelor of Science in Chemistry ______

______ ______

Other departments or units affected by this action. Supply additional information, if needed, on a separate sheet.

		☐	☐
		☐	☐
		☐	☐
		☐	☐
		☐	☐
		☐	☐

Department or unit | Chair or unit head signature (plus date) | Support | Not Support

---

Signatures constitute approval. Signatures by the department chair and the courses and curricula committee chairs certify that the proposal was discussed and approved by a majority of the voting members of the department or committee.

______ ______ ______ ______

Department Chair Date Campus Courses and Curricula Chair Date

______ ______ ______ ______

College Courses and Curricula Chair Date Graduate Dean Date

(Courses numbered 4000-7999)

______ ______ ______ ______

College Dean Date Provost Date

Please proceed to the section below that applies to the action that you are requesting, and provide the appropriate information.

Be sure to describe additional work for graduate credit, if applicable.

Adding a New Course

Course description for a new course

(Please insert **course number** ["xxxx/xxxxG" if appropriate] and **title**, **credit hours**, and **catalog description** in the designated spaces below. You may **NOT** use a course number that has been used previously with the exception of a number for a one-time waiver that is more than five years old.)

CHEM 3091 Chemistry Internship **1-3 cr.**

Prerequisite: Consent of department. Off-campus laboratory or business activities at various commercial or government facilities and institutions that do not have undergraduate programs. Internships are designed to provide practical hands-on laboratory or workplace experience in Chemistry. Students must coordinate an agreement with an off-campus sponsor and are required to submit a written description of their proposed activities for approval by the department prior to enrolling. Requires commitment of a minimum of 3 contact hours per credit hour per week at the off-campus facility. May be used for university general elective credit. May be taken multiple times for a maximum of 9 credit hours.

Justification and explanation for a proposed course, including information about:

- **Why the course is needed**
- **How often the course will be offered**
- **Any enrollment or curriculum restrictions**
- **Anticipated enrollments**
- **Any additional personnel, equipment, or facilities required (if none, indicate 'No additional personnel, equipment, or facilities will be needed.')**

The Department of Chemistry has received feedback from potential employers of our graduates that practical experience in industrial and business settings are essential for our graduates as they transition into their post-graduate careers. Internships also offer the opportunity for our students to gain experience using instruments and techniques that they will not be exposed to in our department. We have existing internship opportunities currently with the New Orleans Crime Lab, St. Tammany Parish Crime Lab, USDA, Eurofins, Chevron and Thionville Laboratories, Inc. These internships have led to multiple of our graduates being hired at these companies. The formalization of the internship program into a class will make it easier to place our students in these companies. Currently we use CHEM 3096 for the internship program, which is our independent study class. By creating CHEM 3091, our students will have an easily identifiable internship class on their transcript instead of the non-descript Independent Study class. The course will be offered every academic semester. There are no prerequisites for the course other than department approval of the internship. Based on previous semester usage of CHEM 3096 for internships, we expect 1-5 students to take this class per semester.

No additional personnel, equipment, or facilities will be needed.

1.6 Syllabus and Contract for CHEM 3091

Chemistry 3091 Syllabus

Disabilities

It is University policy to provide, on a flexible and individualized basis, reasonable accommodations to students who have disabilities that may affect their ability to participate in course activities or to meet course requirements. Students who seek accommodations for disabilities must contact the Office of Disability Services prior to discussing their individual needs for accommodation with their instructors.

Academic Integrity

Students are expected to conduct themselves according to the principles of academic integrity as defined in the statement on Academic Dishonesty in the UNO Student Code of Conduct. Any student or group found to have committed an act of academic dishonesty shall have their case turned over to the Office of Student Accountability and Advocacy for disciplinary action which may result in penalties as severe as indefinite suspension from the University. Academic dishonesty includes, but is not limited to: cheating, plagiarism, fabrication, or misrepresentation, and being an accessory to an act of academic dishonesty.

Additional Resources

Specific resources will vary for this course and will be noted in the Course Contract. General resources are noted below.

SciFinder (scientific literature database available in UNO library)
American Chemical Society Journals (available in UNO library or online through UNO connection at www.acs.org)

Chemistry 3091 Course Contract

Credit Hours: <u>3</u>
Year: <u>2013</u> **Semester: <u>X</u> Fall** ____ Spring ____ Summer
Student Name: **<u>XXXXXX</u>** **UNO ID:** **<u>XXXXXXX</u>**
Faculty Supervisor: **<u>Sean P. Hickey</u>**
Project Title: **<u>Forensics Lab Internship</u>**

Student Learning Objectives:
Student will learn the proper procedures, techniques, chemistry and safety for running instrumentation in a police crime lab. Students will learn proper chain of custody procedures. Fundamentals of chemistry and how they relate to laboratory techniques and experiments will be of utmost importance. Additionally, supervisory and management skills will be learned in the process of this course.

Description of work to be completed by student:
Student will complete 10-15 hours of work per week under direct supervision of Crime Lab Personnel.

Description of deliverables (e.g. research paper, oral presentation, etc.):
Student performance will be assessed by the crime lab supervisor. Student will be asked to present a written summary of his/her experience at the end of the term to the faculty supervisor.

Description of supervision (e.g. how often will student meet with supervisor, etc.):
Student will meet monthly with faculty supervisor. Crime lab supervisor will give weekly reports to the faculty supervisor regarding the performance of the student.

Evaluation and grading criteria:
80% Evaluation of Crime Lab Supervisor
20% Written Report

Acceptance of Course Contract:

___________________________ _________ ___________________________ _________
Student Signature Date Faculty Supervisor Signature Date

Selected bibliography for a proposed course

(Please type, or insert, a bibliography in the space provided below.)

VARIES by Internship.
EXAMPLE CHEMISTRY 3091 COURSE CONTRACT
Credit Hours: 2

Year: 2013 **Semester:** _X_ **Fall** ____ Spring ____ Summer

Student Name: **XXXXXXXX** **UNO ID:** **XXXXXXX**

Faculty Supervisor: Sean P. Hickey

Project Title: **Peptide conjugated nanocrystals**

Student Learning Objectives:

Computerized molecular models of conjugated cellulose nanocrystals

Description of work to be completed by student:

Carry out molecular modeling studies to understand properties

Description of deliverables (e.g. research paper, oral presentation, etc.):

A report and contribution to publication or presentation

Description of supervision (e.g. how often will student meet with supervisor, etc.):

6 hours of work (on two days varying durations of time each day)

Acceptance of Course Contract:

___________________________ ________ ___________________________ ________

Student Signature Date

1.7: Outside Evaluation for CHEM 3091

EXAMPLE CHEMISTRY 3091 OUTSIDE EVALUATION
Fall 2013 Internship Evaluation XXXXXXXXXX

To whom it may concern:

XXXXXXXXX served as an intern at Thionville Laboratories, Inc. for the Fall 2013 semester. During this time, he proved himself to be an exceptional intern. He was highly self-motivated, bright, friendly, and hard-working. He exhibited initiative to learn as much as he could and to make the most out of his internship. I would highly recommend him to any potential employer or graduate school. I would recommend a grade of A+ for XXXXXXX.

Sincerely,

XXXXXXXXXXXXXXX
Assistant Laboratory Director
Thionville Laboratories, Inc.

1.8 Proposal for CHEM 1001

THE UNIVERSITY of NEW ORLEANS

REQUEST TO ADD, DROP, OR CHANGE A COURSE

Departmental Prefix:	**CHEM**	**Existing** or **New** Course No.	**1001**	Credit Hrs.	**3**	CIP:
		Add "G" No. (if applicable)		Credit Hrs.		(For Academic Affairs)

X **ADD A COURSE** (Please proceed to page 3.)

Course Title: **Lights, Camera, ACTION: The Chemistry of Movies and TV**

☐ **DROP A COURSE** (Please proceed to page 6.)

☐ **CHANGE A COURSE** (Check all that apply, then proceed to page 7.)

☐ Course Title

From:

To:

☐ Prerequisite/Description

☐ Credit Hours

From: credit hours

To: credit hours

☐ Course Number (include department prefix/course number)

From: Existing course number Insert "G" number (if applicable)

To: New course number Insert "G" number (if applicable)

☐ Other (Please indicate below)

☐ Non-substantive Use this page for signatures only. Please describe requested change(s) in the box provided on the first page after completing the signature page.

Semester/Year for which change is requested (not later than one academic year from submission date):

Recommended abbreviation for class schedule (include spaces, **ONE LETTER** per box)

L	I	G	H	T	S		C	A	M	E	R	A		A	C	T	I	O	N

For a request to drop or change, where is the most recent description (pdf version of catalog)? page(s)

List all courses and curricula affected by this request. Submit request for other changes **concurrently** with this request.

Other departments or units affected by this action. Supply additional information, if needed, on a separate sheet.

Department or unit	Chair or unit head signature (plus date)	Support	Not Support
		☐	☐
		☐	☐
		☐	☐
		☐	☐
		☐	☐
		☐	☐

Signatures constitute approval. Signatures by the department chair and the courses and curricula committee chairs certify that the proposal was discussed and approved by a majority of the voting members of the department or committee.

Department Chair Date Campus Courses and Curricula Chair Date

College Courses and Curricula Chair Date Graduate Dean Date
(Courses numbered 4000/G-7999)

College Dean Date Provost Date

Please proceed to the section below that applies to the action that you are requesting, and provide the appropriate information.

Adding a New Course

Course description for a new course
Please insert **course number** [“xxxx/xxxxG” if appropriate] and **title**, **credit hours**, and **catalog description** in the designated spaces below. You may **NOT** use a course number that has been used previously.

CHEM 1001 Lights, Camera, ACTION: The Chemistry of Movies and TV 3 cr.

Not offered for credit to fulfill science requirements of students enrolled in the College of Sciences, Allied Health Program, or Science Education. This course fulfills three credits of science requirement for non-science majors. This course will explore how chemistry is portrayed in TV and movies. Students will take basic chemistry principles and learn how to apply them to pop-culture references.

Justification and explanation for a proposed course, including information about:

- **Why the course is needed**
- **How often the course will be offered**
- **Any enrollment or curriculum restrictions**
- **Anticipated enrollments**
- **Any additional personnel, equipment, or facilities required (if none, indicate ‘No additional personnel, equipment, or facilities will be needed.’)**

(Please type in the space provided below.)

Currently, the chemistry department is the only science department that does not offer a non-science majors course. This course (along with the companion CHEM 1011) will fill that void and offer both non-science majors and science majors the opportunity to learn more about how chemistry affects the world around us and compare how “real” chemistry compares to “entertainment” chemistry. We will also be looking into offering CHEM 1010 (and CHEM 1011) as an online course and as a GLOBAL UNO course.

The course will introduce the key concepts of chemistry by using examples from TV and Movies. In general, the format will be to 1) introduce the theoretical concept 2) explain using pop culture references 3) explain further using real-world examples 4) revisit the concept

For example, we would introduce combustion reactions, intermolecular forces and solubility rules, energy, thermodynamics and quantum mechanics (electronic configurations) as the theoretical concept. We would then spend a good bit of time talking about a TV reference that applies to all of those. “Wildfire” from Game of Thrones. The students would be asked to develop based on the theoretical concepts, how they think the chemistry of wildfire works. We would discuss that and then discuss real world phenomena (car engines for combustion; neon signs for energy levels and quantization; bombs and explosives for energy and combustion; deicing of roads, anti-freeze for intermolecular forces. Finally, we would review the theoretical concepts again. This would be done over 2-3 class lectures.

There would be two main units, Movies and TV chemistry. At the end of each unit there would be a test on the chemistry concepts as portrayed in the movies or TV (not about the TV show or movie but about the chemistry). Then there would 3-4 days of presentations by the students. The students would pick a scene from a movie or TV (depending on the unit we are discussing) that shows chemistry and give a 5-7 minute presentation to the class with 2-3 minutes of questions and discussions. These presentations would be done in groups of 2-3 depending on class size. Each student would do a presentation on Movies (for example) and then write a paper for the TV unit (or presentation on TV and paper on Movies). So each student would do one presentation and one paper. The presentations would be graded 50% on the powerpoint, pdf…that is turned in prior to the presentation and 25% my grade of the oral presentation and 25% their classmates grade of the presentation. All students would participate in grading their classmate's performance. These presentations would occur at the end of each unit and the final exam will include some chemistry discussed in the presentations. The papers will be standard 7-10 page research papers.

The course will be offered in the spring semester. As demand grows it will be offered fall, spring and summer.

There are no enrollment restrictions. This course may be taken for general elective credit for science, allied health and science education majors but MAY NOT be taken for science credit by those students. The course may be taken for 3 credits of science elective for non-science majors.

Initial enrollment is expected to be 50-75 students in spring 2014, but we expect to increase to 100+ enrollment in following semesters.

No additional personnel, equipment, or facilities will be needed.

Sample syllabus for a proposed new course

Please type, or insert, a sample syllabus in the space provided below. Remember to describe the work required for graduate credit, if applicable. Please include bibliography.

Course Syllabus
Lights, Cameras, ACTION: The Chemistry of Movies and TV
CHEM 1001—section 001

Instructor:	**Sean P. Hickey**		
College:	**University of New Orleans**		
Semester:	**Spring 2014**	**Credit Hours:**	**3**
Class Time:	**Lecture—(001)**	**XXXXXXXXX**	
Texts:	**Chemistry in Focus by Tro, 5th edition**		
Office:	**UNO CSB 112**		
Office Phone:	**280-1273** (or email at **sphickey@uno.edu)**		
Office Hours:	**XXXXX**		
Prerequisite:	**NONE**		
Class websites:	**https://www.facebook.com/CHEMISTRYofMoviesandTV** **https://www.facebook.com/UNO.Chemistry**		

Course Description:

This is one of two introductory courses (CHEM 1015 and CHEM 1016) that can be taken individually or both taken (in any order) to satisfy either 3 or 6 credits of required science electives for non-science majors. Science majors, allied-health majors and science education majors may take this course for general elective credit but it will not count for science elective credits. This course will explore how chemistry is portrayed in TV and movies. Students will take basic chemistry principles and learn how to apply them to pop-culture references such as found in shows like Breaking Bad, Game of Thrones, Star Trek…and movies such as Jurassic Park.

The course will be broken down into two main units (TV and Movies). For each unit, the theory of a chemical concept will be introduced and then explained first using pop culture references (Wildfire in Game of Thrones; Cooking Meth in Breaking Bad...) and then real-world references (Car combustion, Neon signs, cloning, bombs and explosives...).

Student Learning Outcomes:

After successful completion of this course, Students should:

1. Have an understanding of the Scientific Method and how to apply it to everyday life.
2. Have an understanding of basic chemistry principles including:
    a. Classification of Matter
    b. Atomic and Molecular Theory
    c. Chemical and Physical Changes
    d. Chemical Reactions
    e. Energy transformations
    f. Atomic Structure and Periodicity
    g. Basic Quantum Mechanics
    h. Chemical Bonding and Geometry
    i. Topics in Nuclear Chemistry
    j. Topics in Organic Chemistry
    k. Topics in Environmental Chemistry
    l. Topics in Medicinal Chemistry
    m. Topics in Biochemistry
3. Have an appreciation for the complexity and diversity of chemical processes
4. Understand the difference between "entertainment" chemistry and real chemistry
5. Understand how chemistry affects almost all of our day to day activities
6. Think critically and evaluate portrayal of science in the media
7. Think critically and evaluate day to day processes and how science affects those processes.

Study Methods:

There will be discussions and/or written assignments in class many days. These problems of the day (POD) will make up part of your homework grade.
Additionally, a standing homework assignment will be to read the chapters before coming to lecture. By reading the chapter you will be better prepared to ask questions on the material and will be better able to understand the material being lectured.

Grading and Classroom Procedures:

The drop date is XXXX for nothing to appear on transcript and XXXX for W to appear.
There will be two lecture tests, a paper, presentation and a final exam. The two tests will be worth 300 points. The paper and presentation will each be worth 200 points. Attendance and POD will be worth 100 points. The final exam is cumulative and worth 200 points.

A missed test or assignment will be a zero unless there is an excused, documented absence. If you must miss a test, attempt to let me know ahead of time. There will be no make-up tests except under extreme circumstances. The missed points will be made-up on the next test or final if there is an excused absence. Any makeup test must be arranged at least 48 hours before the test date except for extreme circumstances. You are on your honor to do your own work. Cheating will result in a zero or failure for the term.

Final grades will be based on total points earned during the semester:
A is 900-1000; B is 800-899; C is 700-799; D is 600-699: F is < 600

Presentations:

There will be two main units for this class, Movies and TV chemistry. At the end of each unit there will be a test on the chemistry concepts as portrayed in the movies or TV (not about the TV show or movie but about the chemistry).

Then there will be 3-4 days of presentations. You will get in groups of two or three students and you will pick a scene from a movie or TV (depending on the unit we are discussing) that shows chemistry. Your topic must be approved at least two weeks before the presentations start. Each group will turn in their presentation at least two days before the presentation is given in class. Each group will give a 5-7 minute presentation to the class with 2-3 minutes of questions and discussions.

Each student will do a presentation on Movies (for example) and then write a paper for the TV unit (or presentation on TV and paper on Movies). So each student will do one presentation and one paper. The presentations would be graded 50% on the powerpoint, pdf…that is turned in prior to the presentation and 25% my grade of the oral presentation and 25% your classmates grade of the presentation. All students will participate in grading their classmate's performance and this will be part of your attendance/POD grade. These presentations will occur at the end of each unit and the final exam will include some chemistry discussed in the presentations.

Presentation times will be given out on a first come basis. Once a unit is filled up no more presentations will be allowed in that unit (i.e if there are 15 slots for TV, once all 15 are taken, then only Movie presentations will be available).

Papers:

Each student will do a paper on the unit that they do not do a presentation (so if you chose to do a presentation on movies, you will have to do a paper on TV and vice versa).

The papers will be 7-10 pages long and include:

- Introduction of the chemistry portrayed in the selected media
- Introduction and statement of the chemical concepts that relate
- Description of the chemistry portrayed in the media
- Analysis of how practical and correct the portrayal is to the chemistry
- Critique of how chemistry is viewed and portrayed in media
- Examples of similar portrayals of chemistry and how they relate
- Summary and Conclusion of the analysis
- Cited references from textbook and other scholarly sources
- Appendices with graphs, tables…as needed

Papers will be due on the last day of the unit (per the schedule on the next page)

Cell Phone Utilization Policy:

Cell Phone usage is prohibited in class. Cell phones must be silenced upon entering the classroom. Cell phones may not be used as calculators or for note taking. Any type of cell phone utilization can be cause for dismissal from class. Any exceptions to this regulation must be cleared with the instructor prior to the beginning of class.

Academic Integrity:

Students are expected to conduct themselves according to the principles of academic integrity as defined in the statement on Academic Dishonesty in the UNO Student Code of Conduct. Any student or group found to have committed an act of academic dishonesty shall have their case turned over to the Office of Student Accountability and Advocacy for disciplinary action which may result in penalties as severe as indefinite suspension from the University. Academic dishonesty includes, but is not limited to: cheating, plagiarism, fabrication, or misrepresentation, and being an accessory to an act of academic dishonesty. The Code is available online at **http://www.uno.edu/~stlf/policy%20Manual/judicial_code_pt2.htm**.

Accommodations for Students with Disabilities:

It is University policy to provide, on a flexible and individualized basis, reasonable accommodations to students who have disabilities that may affect their ability to participate in course activities or to meet course requirements. Students who seek accommodations for disabilities must contact the Office of Disability Services prior to discussing their individual needs for accommodation with their instructors.

Attendance Policy:

Attendance is mandatory and will be taken daily in this course. Excessive absences (more than three classes in a row or more than 8 total absences) will be reported to the Provost's Office and may result in termination of federal financial aid as well as negatively affect the student's grade.

Any student with excessive absences will forfeit all bonus points and may not be eligible to benefit from any curve for the class.

Schedule:

Week #1,	Introduction; Syllabus; What is Chemistry?
Week #2,	TV: Chemistry of Breaking Bad
Week #3,	TV: Chemistry of Game of Thrones
Week #4,	TV: Chemistry of Fantasy
Week #5,	TV: Chemistry of Science Fiction
Week #6,	Test #1 (TV unit); Presentations: TV
Week #7,	Presentations: TV
Week #8,	Movies: Chemistry of Jurassic Park
Week #9,	Movies: Chemistry of Action Movies
Week #10,	Movies: Chemistry of Fantasy
Week #11,	Movies: Chemistry of Science Fiction
Week #12,	Test #2 (Movies unit); Presentations: Movies
Week #13,	Presentations: Movies
Week #14,	Presentations: Movies
Week #15,	**Final Exam, XXXXX**

SELECTED BIBLIOGRAPHY:

Chemistry in the Community (ChemCom), American Chemical Society (ACS) ©2011 | Sixth Edition ISBN-13: 9781429219525

Living By Chemistry, Angelica M. Stacy ©2012 | First Edition ISBN-13: 9781559539418

Conceptual Chemistry, Suchocki ©2014 | Prentice Hall | Published: 01/14/2013 ISBN-10: 0321803205 | ISBN-13: 9780321803207

Chemistry for Changing Times, Hill, McCreary & Kolb ©2013 | Prentice Hall | Published: 01/06/2012 ISBN-10: 0321750101 | ISBN-13: 9780321750105

CHEM 2: Chemistry in your world, 2^{nd} edition, John L. Hogg, ISBN-13, 9781133962984, January 2014

The World of Chemistry: Essentials, 4th Edition, Melvin D. Joesten, Mary E. Castellion. John L. Hogg ISBN-13: 9780495012139

Adventures in Chemistry, 1st Edition, Julie T. Millard, ISBN-13: 9780618376629

Chemistry in Focus: A Molecular View of Our World, 5th Edition, Nivaldo J. Tro ISBN-13: 9781111989064

Joy of Chemistry: The Amazing Science of Familiar Things, Promethueus Books, ISBN-13: 978-1591027713

Chemistry Connections, Second Edition: The Chemical Basis of Everyday Phenomena, Academic Press, ISBN-13: 978-0124001510

1.9 Proposal for CHEM 1002

THE UNIVERSITY of NEW ORLEANS

REQUEST TO ADD, DROP, OR CHANGE A COURSE

Departmental Prefix:	**CHEM**	**Existing** or **New** Course No.	**1002**	Credit Hrs.	**3**	CIP:
		Add "G" No. (if applicable)		Credit Hrs.		(For Academic Affairs)

X **ADD A COURSE** (Please proceed to page 3.)

Course Title: **Life, The Universe and Everything: Chemistry of our Daily Lives**

☐ **DROP A COURSE** (Please proceed to page 6.)

☐ **CHANGE A COURSE** (Check all that apply, then proceed to page 7.)

- ☐ Course Title
  - From:
  - To:
- ☐ Prerequisite/Description
- ☐ Credit Hours
  - From: credit hours
  - To: credit hours
- ☐ Course Number (include department prefix/course number)
  - From: Existing course number Insert "G" number (if applicable)
  - To: New course number Insert "G" number (if applicable)
- ☐ Other (Please indicate below)
- ☐ Non-substantive Use this page for signatures only. Please describe requested change(s) in the box provided on the first page after completing the signature page.

Semester/Year for which change is requested (not later than one academic year from submission date):

Recommended abbreviation for class schedule (include spaces, **ONE LETTER** per box)

L	I	F	E	,		T	H	E		U	N	I	V	E	R	S	E		&

For a request to drop or change, where is the most recent description (pdf version of catalog)? page(s) _____

List all courses and curricula affected by this request. Submit request for other changes **concurrently** with this request.

Other departments or units affected by this action. Supply additional information, if needed, on a separate sheet.

		☐	☐
		☐	☐
		☐	☐
		☐	☐
		☐	☐
		☐	☐

Department or unit　　Chair or unit head signature (plus date)
Support　Not Support

Signatures constitute approval. Signatures by the department chair and the courses and curricula committee chairs certify that the proposal was discussed and approved by a majority of the voting members of the department or committee.

Department Chair　Date　Campus Courses and Curricula Chair　Date

College Courses and Curricula Chair　Date　Graduate Dean　Date

(Courses numbered 4000/G-7999)

College Dean　Date　Provost　Date

Adding a New Course

Course description for a new course
Please insert **course number** ["xxxx/xxxxG" if appropriate] and **title**, **credit hours**, and **catalog description** in the designated spaces below. You may **NOT** use a course number that has been used previously.

CHEM 1002 Life, The Universe and Everything: Chemistry of Our Daily Lives 3 cr.

Not offered for credit to fulfill science requirements of students enrolled in the College of Sciences, Allied Health Program, or Science Educations. This course fulfills three credits of science requirement for non-science majors. This course will explore how chemistry affects our daily lives. Students will take basic chemistry principles and learn how to apply them to everyday phenomena such as cooking, energy, nuclear reactors and weapons, biochemical processes and many other chemistry related phenomena.

Justification and explanation for a proposed course, including information about:

- **Why the course is needed**
- **How often the course will be offered**
- **Any enrollment or curriculum restrictions**
- **Anticipated enrollments**
- **Any additional personnel, equipment, or facilities required (if none, indicate 'No additional personnel, equipment, or facilities will be needed.'**

Currently, the chemistry department offers CHEM 1001 as our non-science major course. The new gen ed list of courses has already approved CHEM 1001/1002 as the one-year sequence for non-science majors from the chemistry department.

This course (along with the companion CHEM 1001) fulfills the gen ed requirement for a year of science courses and will offer both non-science majors and science majors the opportunity to learn more about how chemistry affects the world around us. We will also be looking into offering CHEM 1002 as an online course and as a GLOBAL UNO course. The course will be offered in the spring semester. As demand grows it may be offered in the summer. There are no enrollment restrictions. This course may be taken for general elective credit for science, allied health and science education majors but MAY NOT be taken for science credit by those students. Initial enrollment is expected to be 50-100 students in spring 2015 but we hope to increase that to 100-125 students. CHEM 1001 has 77 students in its first offering this term and has been going well so we expect the same for CHEM 1002.

No additional personnel, equipment, or facilities will be needed.

Sample syllabus for a proposed new course
Please type, or insert, a sample syllabus in the space provided below. Remember to describe the work required for graduate credit, if applicable. Please include bibliography.

Course Syllabus
Life, The Universe and Everything: Chemistry of Our Daily Lives
CHEM 1011—section 001

Instructor: Sean P. Hickey
College: University of New Orleans
Semester: Spring 2015 Credit Hours: 3
Class Time: Lecture—(001) TTH 2-315
Texts: CHEM 2: Chemistry in your world, 2nd edition, John L. Hogg, ISBN-13, 9781133962984, January 2014

Office: UNO CSB 112
Office Phone: 280-1273 (or email at sphickey@uno.edu)
Office Hours: XXXXX
Prerequisite: NONE
Class websites: https://www.facebook.com/CHEMISTRYofMoviesandTV
https://www.facebook.com/UNO.Chemistry
Course Description:

This is one of two introductory courses (CHEM 1001 and CHEM 1002) that can be taken individually or both taken (in any order) to satisfy either 3 or 6 credits of required science electives for non-science majors. Science majors, allied-health majors and science education majors may take this course for general elective credit but it will not count for science elective credits. This course will explore how chemistry affects our everyday lives. You will take basic chemical principles and apply them to everyday phenomena such as cooking, energy, nuclear reactors and bombs, biochemical processes and other daily phenomena.

Study Methods:
There will be discussions and/or written assignments in class many days. These problems of the day (POD) will make up part of your homework grade. Additionally, a standing homework assignment will be to read the chapters before coming to lecture. By reading the chapter you will be better prepared to ask questions on the material and will be better able to understand the material being lectured.

Student Learning Outcomes:
After successful completion of this course, Students should:

Have an understanding of the Scientific Method and how to apply it to everyday life.
Have an understanding of basic chemistry principles including:
Classification of Matter
Atomic and Molecular Theory
Chemical and Physical Changes
Chemical Reactions
Energy transformations
Atomic Structure and Periodicity
Basic Quantum Mechanics
Chemical Bonding and Geometry
Topics in Nuclear Chemistry
Topics in Organic Chemistry
Topics in Environmental Chemistry
Topics in Medicinal Chemistry
Topics in Biochemistry
Topics in Fuel Chemistry
Topics in Materials Chemistry
Have an appreciation for the complexity and diversity of chemical processes
Understand how chemistry affects almost all of our day to day activities
Think critically and evaluate day-to-day processes and how science affects those processes.
Grading and Classroom Procedures:

The drop date is XXXX for nothing to appear on transcript and XXXX for W to appear. There will be three lecture tests, 1 paper and 2 presentations. The three tests will be worth 300 points. The papers and presentation will each be worth 200 points. Attendance and POD will be worth 100 points.

A missed test or assignment will be a zero unless there is an excused, documented absence. If you must miss a test, attempt to let me know ahead of time. There will be no make-up tests except under extreme circumstances. The missed points will be made-up on the next test or final if there is an excused absence. Any makeup test must be arranged at least 48 hours before the test date except for extreme circumstances. You are on your honor to do your own work. Cheating will result in a zero or failure for the term. Final grades will be based on total points earned during the semester:
A is 900-1000; B is 800-899; C is 700-799; D is 600-699: F is < 600

Tests, Presentations and Papers

There will be three main units for this class, 1) Life 2) the Universe and 3) Everything. At the end of each unit there will be a test on the chemistry concepts we talked about for each unit. Each student will form a learning community (group of 4-6 students). Those learning communities will present a paper, an in-class presentation and out of class presentation/media project for one of the units in the class. Your learning community will stay and work together all semester long on these three projects. You will pick which unit you want to do each task. For example, you can chose to give a presentation on the Life unit, write a paper on the Universe unit and do an out of class presentation/media performance on the Everything unit. We will discuss this more the first day of class.

Presentations:

There will be one day of presentations at the end of each unit. Your learning community will pick your unit and your presentation topic. Your topic must be approved at least two weeks before the presentations start. Each group will turn in their presentation at least two days before the presentation is given in class. Each group will give a 10-12 minute presentation to the class with 2-3 minutes of questions and discussions.

Each learning community will do a presentation either for Life, the Universe or Everything. The presentations will be graded 50% on the powerpoint, pdf…that is turned in prior to the presentation and 25% my grade of the oral presentation and 25% your classmates grade of the presentation. All students will participate in grading their classmate's performance and this will be part of your attendance/POD grade. These presentations will occur at the end of each unit.

Presentation times will be given out on a first come basis. Once a unit is filled up no more presentations will be allowed in that unit (i.e if there are 6 slots for "Life", once all 6 are taken, then only "the Universe" and "Everything" presentations will be available).

Papers:

Each learning community will do a paper based on the unit that they are not doing an in-class presentation or media project. The paper will be approx. 10 pages long. Each person in the group will contribute as section and the group will edit the overall paper to provide a cohesive team project. The paper will focus on a specific topic in the appropriate unit.

Introduction of the chemistry
Explanation of the chemical concepts that relate
Analysis of how chemistry affects our daily lives
Critique of how chemistry is viewed and portrayed in media
Summary and Conclusion of the analysis
Cited references from textbook and other scholarly sources

Papers will be due on the last day of the unit.

Out of class media projects:

Each learning community will do a media presentation based on the unit that they are not doing an in-class presentation or paper. You can be as creative as you want. You can create a song, do a video or just give a "web" presentation. They should be 5-10 minutes long. We will be posting these online (probably on our class Facebook page). You will be graded on your originality, creativity and how you explain the chemistry. You should also make comments (constructive and nice) about other students work. For example, you could chose cooking in chemistry and record a video of you cooking something and explain the chemistry that is going on during your meal. Or you could do a video on photography and do a video showing how to develop film. Just be creative. Presentations will be due on XXXX (date to be determined)

Cell Phone Utilization Policy:

Cell Phone usage is prohibited in class. Cell phones must be silenced upon entering the classroom. Cell phones may not be used as calculators or for note taking. Any type of cell phone utilization can be cause for dismissal from class. Any exceptions to this regulation must be cleared with the instructor prior to the beginning of class

Academic Integrity:

Academic integrity is fundamental to the process of learning and evaluating academic performance. Academic dishonesty will not be tolerated. Academic dishonesty includes, but is not limited to, the following: cheating, plagiarism, tampering with academic records and examinations, falsifying identity, and being an accessory to acts of academic dishonesty. Refer to the Student Code of Conduct for further information.

The Code is available online at http://www.studentaffairs.uno.edu.

Accommodations for Students with Disabilities:

It is University policy to provide, on a flexible and individualized basis, reasonable accommodations to students who have disabilities that may affect their ability to participate in course activities or to meet course requirements. Students with disabilities should contact the Office of Disability Services as well as their instructors to discuss their individual needs for accommodations. For more information, please go to http://www.ods.uno.edu.

Attendance Policy:

Attendance is mandatory and will be taken daily in this course. Excessive absences (more than three classes in a row or more than 8 total absences) will be reported to the Provost's Office and may result in termination of federal financial aid as well as negatively affect the student's grade.

Any student with excessive absences will forfeit all bonus points and may not be eligible to benefit from any curve for the class.

Schedule:

UNIT #1	Life
Week #1,	Introduction; Syllabus; Sugars, Proteins and Lipids
Week #2,	Biochemistry and Comparative Biochemistry
Week #3,	Drugs and Medicinal Chemistry
Week #4,	Cloning and Presentations
Week #5,	Presentations and Test #1
UNIT #2	Universe
Week #6,	The Sun, Our Salvation; Electromagnetic Spectrum
Week #7,	Nuclear Options (Nuclear Fission, Fusion and Bombs)
Week #8,	Fossil Fuels, Energy of the Past and the Future
Week #9,	Alternate Energy and Atmospheric/Environmental Chemistry
Week #10,	Presentations
Week #11,	Presentations and Test #2
UNIT #3	Everything
Week #12,	Nanotechnology and Materials
Week #13,	Molecular Gastronomy and Food
Week #14,	Explosions and Reactivity
Week #15,	Presentations
Week #16,	Presentations and Test #3

SELECTED BIBLIOGRAPHY:

Chemistry in the Community (ChemCom), American Chemical Society (ACS) ©2011 | Sixth Edition ISBN-13: 9781429219525

Living By Chemistry, Angelica M. Stacy ©2012 | First Edition ISBN-13: 9781559539418

Conceptual Chemistry, Suchocki ©2014 | Prentice Hall | Published: 01/14/2013 ISBN-10: 0321803205 | ISBN-13: 9780321803207

Chemistry for Changing Times, Hill, McCreary & Kolb ©2013 | Prentice Hall | Published: 01/06/2012 ISBN-10: 0321750101 | ISBN-13: 9780321750105
CHEM 2: Chemistry in your world, 2nd edition, John L. Hogg, ISBN-13, 9781133962984, January 2014

The World of Chemistry: Essentials, 4th Edition, Melvin D. Joesten, Mary E. Castellion. John L. Hogg ISBN-13: 9780495012139

Adventures in Chemistry, 1st Edition, Julie T. Millard, ISBN-13: 9780618376629
Chemistry in Focus: A Molecular View of Our World, 5th Edition, Nivaldo J. Tro
ISBN-13: 9781111989064

Joy of Chemistry: The Amazing Science of Familiar Things, Promethueus Books,
ISBN-13: 978-1591027713

Chemistry Connections, Second Edition: The Chemical Basis of Everyday Phenomena, Academic Press, ISBN-13: 978-0124001510

Molecular Gastronomy: Exploring the Science of Flavors, Columbia University Press,
ISBN-13 978-0231133136

Culinary Reactions: The Everyday Chemistry of Cooking, Chicago Revie Press, ISBN-13 978-1569767068

What Einstein Told His Cook: Kitchen Science Explained, WW Norton & Co.
ISBN-13 978-0393329421

Appendix 2 Student Evaluation Given Fall 2016

Recipient Last Name
Recipient First Name
Recipient Email
Your information - Last Name
Your information - First Name
Your information - Student ID#
What is your major(s) or classification? Select all that apply. (Biology, Chemistry, Pre-medical, Pre-Dental, Other pre-professional, Post-baccalaureate, other)
Are you exempt from the final Exam (Yes, no)
Expected grade in this course (A, B, C, D, F)
What is your chemistry background?
Throughout the semester, my study methods:
I used the following to study for the test (select all that apply)
Rank the study aids by importance to your getting a good grade (1 = most important; 8 = least important) - Textbook
Rank the study aids by importance to your getting a good grade (1 = most important; 8 = least important) - ORION
Rank the study aids by importance to your getting a good grade (1 = most important; 8 = least important) - Practice Tests
Rank the study aids by importance to your getting a good grade (1 = most important; 8 = least important) - Wiley Plus Mastery Homework
Rank the study aids by importance to your getting a good grade (1 = most important; 8 = least important) - Lecture Study Guides
Rank the study aids by importance to your getting a good grade (1 = most important; 8 = least important) - Lecture Videos (iTunes)
Rank the study aids by importance to your getting a good grade (1 = most important; 8 = least important) - Recitations
Rank the study aids by importance to your getting a good grade (1 = most important; 8 = least important) - Online help (google, khan academy...)
Rank each of the following study aids (more than one study aid can have the same ranking..i.e you could say practice tests and ORION are both extremely useful...) - Textbook
Rank each of the following study aids (more than one study aid can have the same ranking..i.e you could say practice tests and ORION are both extremely useful...) - ORION
Rank each of the following study aids (more than one study aid can have the same ranking..i.e you could say practice tests and ORION are both extremely useful...) - Practice Tests
Rank each of the following study aids (more than one study aid can have the same ranking..i.e you could say practice tests and ORION are both extremely useful...) - Wiley Plus Mastery Homework

Rank each of the following study aids (more than one study aid can have the same ranking..i.e you could say practice tests and ORION are both extremely useful...) - Lecture Study Guides
Rank each of the following study aids (more than one study aid can have the same ranking..i.e you could say practice tests and ORION are both extremely useful...) - Lecture Videos
Rank each of the following study aids (more than one study aid can have the same ranking..i.e you could say practice tests and ORION are both extremely useful...) - Recitations
Rank each of the following study aids (more than one study aid can have the same ranking..i.e you could say practice tests and ORION are both extremely useful...) - Online help (google, khan academy...)
Which textbook did you buy for this class?
Where did you buy your textbook?
Answer these questions about the textbook, lecture notes.... - I found the textbook very readable.
Answer these questions about the textbook, lecture notes.... - The textbook was well-organized with chapters building upon previous material.
Answer these questions about the textbook, lecture notes.... - There were plenty of worked examples and practice problems.
Answer these questions about the textbook, lecture notes.... - The textbook's explanations were thorough and self-explanatory.
Answer these questions about the textbook, lecture notes.... - I felt that I could have performed very well in this course just by reading the textbook alone.
Answer these questions about the textbook, lecture notes.... - I felt the lecture notes supplemented the textbook well.
Answer these questions about the textbook, lecture notes.... - I felt the lecture notes filled in the holes that were missing from the textbook.
Answer these questions about the textbook, lecture notes.... - I felt that I could have performed very well in this course just by reading the lecture notes alone.
Answer these questions about the textbook, lecture notes.... - The lecture notes were well-organized.
Answer these questions about the textbook, lecture notes.... - I felt that the textbook and lecture notes were a great compliment to each other.
Choose the following statement about the lecture notes that describes you:
Choose the statements about the lecture notes that describes you:
Did Wiley Plus help you study for the tests?
Which part of Wiley Plus helped the most?
Rank the Wiley Plus parts by importance to your getting a good grade (1 = most important; 5 = least important) - ORION
Rank the Wiley Plus parts by importance to your getting a good grade (1 = most important; 5 = least important) - Mastery Assignments

Rank the Wiley Plus parts by importance to your getting a good grade (1 = most important; 5 = least important) - Pre-lecture Assignments
Rank the Wiley Plus parts by importance to your getting a good grade (1 = most important; 5 = least important) - Mechanism Explorer Questions
Rank the Wiley Plus parts by importance to your getting a good grade (1 = most important; 5 = least important) - Ebooks and Videos
Usefulness - ORION
Usefulness - Mastery Assignments
Usefulness - Pre-lecture Assignments
Usefulness - Mechanism Explorer Questions
Usefulness - Ebooks and Videos
Time to complete assignment - ORION
Time to complete assignment - Mastery Assignments
Time to complete assignment - Pre-lecture Assignments
Time to complete assignment - Mechanism Explorer Questions
Time to complete assignment - Ebooks and Videos
Did you use this effectively - ORION
Did you use this effectively - Mastery Assignments
Did you use this effectively - Pre-lecture Assignments
Did you use this effectively - Mechanism Explorer Questions
Did you use this effectively - Ebooks and Videos
How many recitations did you attend?
Which of the following are true of recitations in learning material and preparing for test? Select all that apply.
Rate your TA on their knowledge, preparedness... - My TA was very prepared for recitation
Rate your TA on their knowledge, preparedness... - My TA was knowledgeable about the material
Rate your TA on their knowledge, preparedness... - My TA was very helpful in recitation
Rate your TA on their knowledge, preparedness... - My TA was willing to help
Rate your TA on their knowledge, preparedness... - My TA helped me understand some of the harder concepts
How often did you click in for attendance?
Which of the following are true of Top Hat questions in learning material and preparing for test? Select all that apply.
What are the major strengths of this course?
What are the major weaknesses of this course?
What would you recommend to improve the course?

Appendix 3 Copyright Permission from Wiley Publishing

Subject: RE: Request for permission to use content from WileyPLUS in Dissertation
Date: Friday, May 31, 2019 at 4:12:41 AM Central Daylight Time
From: Wiley Global Permissions
To: Sean Patrick Hickey
Attachments: image002.jpg, image003.png

Dear Sean,

Thank you for your email.

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Any third-party material is expressly excluded from this permission. If any material appears within the article with credit to another source, authorisation from that source must be obtained.

Should you require any further information, please do not hesitate to contact me.

Kind regards,

Paisley Chesters
Permissions Co-Ordinator

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PO19 8SQ
www.wiley.com

WILEY

Vita

The author was born in Metairie, LA. He obtained his Bachelor's degree in chemistry from the University of New Orleans in 1992. He then attended the University of Michigan receiving a Master's degree in chemistry in 1994. He then embarked on a teaching career that included working for a semester as a lecturer at the University of Michigan in 1995. Followed by a year teaching high school chemistry at Holy Cross High School in New Orleans (1995-1996). He then became employed at Delgado Community College as an assistant professor of physical sciences (1996-2001). During this time, he also taught adjunct at William Carey School of Nursing and Nunez Community College.

He then joined UNO at the science supply manager in 2001 where he was employed full time till 2014. During his career at UNO, he became the business manager for chemistry and spent most of his career teaching organic chemistry for 50% of his duties and management for 50% of his duties. During his time at UNO, he also was an adjunct professor at Holy Cross College and William Carey College in addition to working as a chemistry consultant for Wiley publishing. In 2014, he joined Wiley publishing fulltime as the product designer for online content for all chemistry textbooks published by Wiley. Concurrent with joining Wiley fulltime the author joined the PhD program at UNO focusing on chemical education research in Dr. Matthew Tarr's group. He continued working at UNO and Wiley through 2017. In 2017, the author left Wiley and joined Xavier University of Louisiana as a lecturer of organic chemistry while continuing to work on his PhD at UNO. The author will join the faculty of Wayne State University in fall 2019 as a senior lecturer of chemistry.

In addition to his work as a faculty, the author has been heavily involved in the local ACS holding the positions of secretary, chair-elect, chair, past-chair and member at large numerous times over the past 16 years. The author has also been the general chair of the 2010 and 2020 Joint SWRM/SERMACS meeting in New Orleans. He has also been the secretary/treasurer of SWRM regional board since 2010 and a member of the executive board/steering committee since 2004. He has also served on the executive board/steering committee of SERMACS regional board from 2009-2011 and 2019-2021.