Using Technology to Create an Active, Collaborative Learning Environment: Even in Organic Chemistry!

William M. Wuest
Department of Chemistry
Temple University

Liesl M. Wuest
Fox School of Business, Department of Online and Digital Learning
Temple University

Abstract

The Seven Principles of Good Practice in Undergraduate Education by Arthur W. Chickering and Zelda F. Gamson (1987) stress active and collaborative learning, but this can seem difficult to implement in large STEM classes. Herein, we highlight ways to integrate the active and collaborative principles into large classes and discuss how technology can be used to meet the other principles as well. Taking advantage of easy-to-use and readily available technological solutions like Socrative and a variety of media outlets, students have improved test scores and report higher overall satisfaction in a class that is often students' least favorite—organic chemistry.

Introduction

Organic chemistry has historically been viewed as the gatekeeper course for all students interested in pursuing careers in the health sciences. Many professional programs ranging from medical to dental school require a passing (and in most cases higher) grade. As is typical in most physical science courses, students are intimidated by the material and dread the class. This results in students with low expectations and little hope for an enjoyable learning experience. It is in this pretense that we sought to change the status quo of organic chemistry by making it approachable and engaging.

Over the past three years we have developed and implemented a strategy focused on creating both an active and collaborative learning environment within the confines of a material laden curriculum. The amount of course content that is covered in a typical semester of Organic Chemistry is daunting. Students at Temple University are expected to master thirteen chapters (over 650 pages) of textbook material in a fourteen-week semester, a difficult task for even the most seasoned instructors. Therefore, to be successful one must strategically plan to maximize both in-class and out-of-class learning through a blend of techniques.

To accomplish this goal we instituted a method that removes a portion of the traditional lecture time and replaces it with peer-involved problem solving exercises and activities. Using technology to facilitate this transformation, we rethought the class structure and atmosphere to increase student motivation creating a welcoming classroom experience where the students are actively involved in the lecture. Based on standardized department testing we were able to compare the learning outcomes of the students within our section where active and collaborative techniques were used to those taught with traditional lecturing. We found that students in the interactive environment performed significantly better in each of the two years that this study was conducted with an 8.9% and 15.7% overall improvement compared to the other sections.

Literature Review

Providing an active and collaborative learning environment is not a new concept. In 1987, Arthur Chickering and Zelda Gamson published their research entitled "Seven Principles for Good Practice in Undergraduate Education" which emphasized student-faculty interaction, active learning, and effective communication (Chickering & Gamson, 1987). The seven principles are as follows:

> Good Practice 1) Encourages Student-Faculty Contact; 2) Encourages Cooperation Among Students; 3) Encourages Active Learning; 4) Gives Prompt Feedback; 5) Emphasizes Time on Task; 6) Communicates High Expectations; and 7) Respects Diverse Talents and Ways of Learning.

When looking at these seven concepts it soon became apparent that these were specific ways to help engage students in active and collaborative learning. Thus, rather than stress seven items for faculty to focus on, we grouped them together to focus on how big-picture strategies—an active classroom and a collaborative attitude—can affect student outcomes keeping in mind the specific recommendations of the principles.

Active learning, simply put, is practice! As Ambrose, Bridges, DiPietro, Lovett, & Norman (2007) point out in *How Learning Works,* students gain mastery with focused, repetitive practice. It is especially important for students to practice component skills when learning subjects with complex information to help them understand context and recognize patterns (Ambrose et al., 2007). When students are given time to reflect on the material and come to the conclusions on their own they are able to better generate a schemata for the subject that will have long-lasting effects as opposed to short-term memorization for a test that they soon forget (Mastacusa, Snyder, & Hoyt, 2011). The principles that we grouped under active learning are #2, #3, #5 and #7 (Chickering & Gamson, 1987).

Collaboration, while often a form of active learning in itself, brings additional benefits. In his book *Leaving the Lectern*, Dean McManus (2005) cites previous research that shows improved learning outcomes when students work together. He says that when students collaborate and share their collective knowledge they are better able to arrive at the correct solution and reflect on what they did to get the correct solution as a group. This type of reflective practice will continue to help the students build a strong foundation of knowledge thereby making it easier for them to understand increasingly complex information as they move through the class. In addition, demonstrating effective learning techniques in class provides students with an example of how they can effectively study for high stakes exams. The principles that we grouped under collaborative learning are #1, #4, #6 and #7 (Chickering & Gamson, 1987).

Methodology

At the onset of teaching this course we wanted to integrate various strategies that would make the class both active and collaborative. With the seven principles in mind we identified six distinct methods by which we could accomplish these goals and summarize the benefits that these changes made below.

Using E-mail to Provide Feedback and Encouragement [Principles #1, #4, #6]
Most faculty members are familiar with e-mail, especially from eager students in the classroom. However, few effectively use e-mail to their advantage for providing assessment information or as a means for general encouragement. We have found that students appreciate personal emails expressing both excitement and disappointment regarding their performance on exams. We specifically target a subset of the class who have either greatly improved or declined in their outcomes to either continue to encourage or to identify what has changed. Not only does this exercise please the students but it also provides important feedback to the instructor regarding concepts that were not clearly presented or understood.

Leveraging Learning Management Systems (LMS) to Off-load Classroom Content [Principles #5, #6, #7]
A critical component to the success of an active and collaborative environment is a class that comes prepared and ready to learn. To help facilitate this process we utilize Blackboard, an LMS, as a repository for lecture

notes, handouts, links to Khan Academy videos, and old exams thereby allowing students unlimited access to the course material both before and after the class. Students are expected to come to class having already gone through the material ahead of time. Because of this, the pace of the lecture portion is faster allowing more class time to practice difficult concepts. Those who do not come to class prepared quickly find themselves falling behind.

Combining Immediate Feedback Assessment Techniques (IF-AT) with Current Mobile Technologies to Improve Classroom Engagement [Principles #3, #4, #5, #6, #7]
Previous research has demonstrated that using IF-AT devices (commonly known as "clickers") in the classroom greatly increases student learning (Caldwell, 2007 & Wood, 2004). However, "clickers" are cumbersome, costly, and limited to multiple-choice questions. To overcome these obstacles we identified an alternative that best meets these requirements. *Socrative* is an IF-AT service that is available to colleges at a nominal cost but it allows students to use their SmartPhones or computers to participate in class free of charge. *Socrative* also provides the instructor with more options for asking questions in class, allowing free response questions in addition to multiple-choice. We discovered that over 90% of students found *Socrative* useful for an in-class exercise. As instructors, we appreciated the feedback in real time, during class, where we could address fundamental misunderstandings instantly. It also encourages students to come to class prepared because while their specific responses are anonymous, they are still motivated to choose the correct response as the question and answer rates are shown for everyone to see.

Integrating Group Work Strategically Throughout the Lecture [all principles!]
Through our experience teaching information heavy classes, we have found that material is best delivered in 15-20 minute intervals interspersed with problem-solving activities. In a typical class we prepare our lecture in the following manner: ten minutes introducing/defining a topic and the guidelines, five minutes demonstrating how an "expert in the subject" would solve the problem, and 10-15 minutes providing examples for the students to work on in small groups. The key to success for this type of approach is two-fold. First, students need to come to class prepared and familiar with the material, otherwise they will not be able to sustain the pace by which material is introduced. Second, the professor (and if possible a teaching assistant) needs to be actively involved in the problem solving exercise, moving throughout the room and ensuring that all students are on the right track. We would sometimes recognize that a key concept was not clear to students and would stop the problem solving exercise to reteach the theory. This approach was favorably viewed by a large majority of the class and lead to many unintended benefits. For example, new study groups formed and met outside of class promoting a collaborative atmosphere where students supported, instead of competed against, one another.

Developing In-class Games to Engage and Energize the Classroom [Principles #2, #3, #4, #5, #6, #7]
Previous research has demonstrated that classroom engagement through educational games improves learning outcomes (Barab, S. A., Gresalfi, M., & Arici, A., 2009;Squire, K. & Jenkins, H., 2003). With this work in mind we wanted to develop an activity that would simultaneously accomplish three specific goals necessary to excel in organic chemistry – 1) integrate strong students with weaker students, 2) develop a method to focus time on task (to prepare students for a timed final exam), and 3) create a fun activity that students enjoy. Toward this end, we were inspired by a bar trivia game called Quizzo (similar to Jeopardy). In the game, students work together to answer multiple-choice or free response questions during the length of one entire musical song, after which the answers are due. The game is made up of several rounds and the team with the most points at the end of the game wins. We have found that pairing weaker students with stronger not only has benefits for both groups of students during the game, but often fosters new, well-balanced study groups. Overall, the experience is well received by the students resulting in greater than 95% attendance on the days when the game is played.

Creating Content-driven Music Videos to Solidify Fundamental Understanding [Principles #2, #3, #7]
Temple University, situated in Northern Philadelphia, contains a diverse population of students with a variety of interests. In the classes that we have taught, we have had majors varying from chemistry and biology to more untraditional areas like art history and photography. We wanted to leverage these talents and also accommodate students with an additional method of learning so we introduced the idea of creating music videos to highlight the material that was taught during the semester. The premise was simple – create and upload a three-minute music video to YouTube and the best video, as voted on by the students, would be given extra credit (thereby not penalizing students who have not made a video). We have had tremendous success, with over 25% of students submitting videos, even though the activity is completely voluntary. While we are not the first to use music as a forum for learning (Crowther, 2004), we have found improved student outcomes from the students who did participate in the extra-credit activity and hope to encourage other faculty to give students a variety of ways to practice and demonstrate their knowledge.

Conclusion

Over the past two years we have collected and analyzed test data to determine if these methods have improved student outcomes. We were interested in two specific questions – 1) Do the music videos provide any benefit to the students who create them? and 2) Do active and collaborative teaching methods increase learning in organic chemistry? To investigate the former, we divided the data from our class into two groups – those who had made videos and those who had not. Throughout the year, those who made the videos typically outperformed those who did not. However, what was both surprising and satisfying was that on the exam immediately following the submission of the music videos, the difference between the two groups doubled. It should be noted that this is typically the most difficult exam of the year and highlights the benefit of such an activity.

Previous research has clearly demonstrated that active and collaborative learning improves student outcomes (Ambrose et al., 2010; Mastacsusa et al., 2011). We wanted to determine if this was true in our department using the standardized testing that was already in place. Our department administers common review exams during the first week of class and common final exams at the end of class. (Both exams are multiple choice tests given nationwide with a mean average of 50%). Using this data we were able to see clear and marked improvement in each of the two semesters that this class was taught. During Spring 2013, the 71 students in our course came into the class 1.4% below the other 140 students' review exam average. However, they outperformed the other students by 7.5% on the final exam leading to an overall improvement of 8.9%. Even more impressive was the improvement in the following semester. Our class (96 students) entered 7.4% below the others (291 students) but exited 8.3% above resulting in a remarkable 15.7% overall improvement! These results strongly indicate that the teaching methods presented in this paper coupled with a supportive and cooperative classroom atmosphere generate significant improvement in the learning outcomes of students. In conclusion, we have successfully demonstrated that active and collaborative teaching methods can be used in a material laden class like Organic Chemistry to improve student satisfaction and outcomes, turning a class that is universally feared into one that is manageable and even, dare we say, enjoyable.

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