Engaging science students with wireless technology and applications by re-visiting the Thayer method of teaching and learning

Richard PENNINGTON, David PURSELL, Joseph SLOOP

Chemistry Program, School of Science & Technology, Georgia Gwinnett College
Lawrenceville, GA 30043, USA

ABSTRACT

Undergraduate science instructors at Georgia Gwinnett College (GGC) used wireless technology and applications to re-visit the Thayer Method of teaching and learning to create an updated method that works with and engages 21st century students. The method used by instructors at GGC currently focuses on the general and organic chemistry courses and emphasizes use of a detailed syllabus and wireless applications that guide student preparation before class, instructor Q/A to gauge progress at the beginning of class, student problem solving “at the boards” during class and frequent feedback via quizzes. As students prepare (anywhere and anytime in a mobile environment), they may access smart phone viewable course materials - “flashcards” containing basic chemical nomenclature, structures, and reactions, and mini-lectures of course content prepared using the Smart Board Airliner. Coupled with a student friendly text, these smart phone applications enable substantial student preparation, maximizing accomplishment of the underlying premise of the Thayer Method. This paper and presentation describes the components of the updated Thayer Method, and to illustrate its implementation in our principles of chemistry and organic chemistry courses, provides video segments of actual student-instructor class time, as well as audio and written examples of student comments. Students and instructors have found this approach to learning preferable to the traditional lecture presentation.

Keywords:
Undergraduate, science education, chemistry education, multimedia based learning; computer based learning, wireless application, Thayer Method.

INTRODUCTION

“It’s not about the gizmo (holding up a smart phone for a group of newly hired faculty to see), it’s about using the gizmo to enhance student learning.”

Many students find chemistry courses exceptionally challenging because of the depth and breadth of content, the rapid pace of the course and, particularly in the case of organic chemistry, the notion that each successive lesson builds directly on previous lessons over the course of the entire year-long sequence. In fact, students know organic chemistry as “the infamous, dreaded ‘orgo’, a marathon of memorization.” Such sentiment is common among students about to begin undergraduate organic chemistry, as at most schools between 25-50% of students do not continue to the second semester.

There has been much research on pedagogical approaches to teaching demanding, rigorous courses such as general and organic chemistry. Often the first semester chemistry course is a large lecture course with recitation sections and a separate laboratory course. A very common occurrence is that different instructors teach the lecture and laboratory components of a chemistry course – in fact, many institutions employ instructors to specifically teach only sections of chemistry laboratory. Such pedagogy has limitations and educators have experimented with many alternative approaches.

These studies indicate that there is enhanced learning and greater student satisfaction when the traditional lecture course is supplemented with other instructional techniques; employment of a variety of these techniques at GGC, including the use of wireless technology, will be described in this paper.
METHODOLOGY

General and organic chemistry courses at GGC are taught in small sections with no more than 24 students, and this small section size offers many opportunities for instructional flexibility. The instructors use a version of the Thayer Method, named for Sylvanus Thayer, the Superintendent of the United States Military Academy at West Point, from 1817-1833. Thayer increased academic rigor and made the focus of the academic program to train civil engineers for the growing nation. The Thayer Method views teaching as supporting student learning, and its hallmark is that students prepare prior to class, so each lesson is published in advance with student lesson objectives (Figure 1), reading assignments and homework problems. Essentially, there exists a contract whereby students commit to preparing before class and instructors commit to flexibility in facilitating student learning during class. Each class period is 75 minutes long, which allows for the following format for each class:

- Q&A session at the start of each class where the students can ask about problems they experienced with the assigned homework problems.
- Chemical demonstrations and discussion as needed
- On-the-fly instructor mini-lectures for more complex material.
- Students demonstrating their proficiency of the material by working problems in groups at the whiteboards (this usually constitutes the largest portion of class time)
- Lesson/Chapter quizzes to provide frequent feedback, so students always know how they are doing in the class.

This interactive class format allows for student recitation under the guiding and mentoring eye of the instructor. The lab program is also directly integrated with the class, using the same instructor for each lab and class section.

In order to augment the effectiveness of the Thayer Method at GGC, methods were investigated that would supplement the traditional pedagogical approaches with instruction adapted to the life and learning style of today’s generation of students that enables us to accomplish the objectives of the Thayer Method, thus maximizing efficiency and effectiveness of instructor-student contact time.

Our search led us to engaging students with handheld technology and applications tailored for chemistry. Students already demonstrate facility with basic cell phones for voice and text messaging, so our intent was to allow the students to use their cell phones to access course materials - such as reaction, structure and nomenclature flash cards, preparatory video mini lectures, and experimental technique demonstration videos - using a device that they normally have with them all of the time. Use of these would enable engagement and student preparation outside of the classroom in order to maximize the effectiveness and efficiency of faculty-student contact time during class and lab periods.

Currently, GGC students have access to digital flash cards for such topics as polyatomic ions (Figure 2), organic chemistry functional groups (Figure 3), organic chemistry reactions (Figure 4) and chemical nomenclature to name but a few. Students have the option to view these cards either on their computer or with their cell phone. However, while only a limited number of students have sufficiently smart phones to use these applications at GGC, they have been very favorably reviewed. A Likert scale survey (Table 1) captured the positive student attitude about both the importance of learning organic chemistry reactions and the organic cell phone flash cards as a tool to help them learn. Students especially appreciated the value of cell phones that are always with them as opposed to more traditional tools, so that they may study the material any time and any place. The following statements illustrate their positive attitude concerning cell phone flash cards:

---

**Spring 2010 – CHEM 2212 Organic Chemistry II – Daily Lesson Objectives**

**ALCOHOLS, PHENOLS AND THIOLS; ETHERS AND SULFIDES (CH. 13)**

**Day 1 (I/11/10) – Introduction to CHEM 2212 / Start of Chapter 13**

-Read Ch. 13.1 - 13.2
- Problems before class: 13.1 - 5
- Videos to watch in preparation for class; naming alcohols

- Name and draw the structures of alcohols, phenols and thiols
- Describe trends in physical properties of alcohols, phenols and thiols
- Demonstrate how alcohols are both weakly acidic and weakly basic
- Draw resonance structures to explain the higher acidity of phenols vs alcohols

- Problems during and after class: 13.20, 24a-e, 25, 27, 50

---

**Figure 1 - Examples of Daily Lesson Objectives used at GGC**
Table 1. Organic chemistry cell phone flash card student survey

<table>
<thead>
<tr>
<th>Respond to the statements using the scale below:</th>
<th>Ave</th>
<th>Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Learning organic reactions is important to learning organic chemistry.</td>
<td>5.0</td>
<td>0.00</td>
</tr>
<tr>
<td>1. I find learning organic reactions challenging.</td>
<td>4.5</td>
<td>0.58</td>
</tr>
<tr>
<td>1. Learning organic reactions is critical to the higher level task of doing organic synthesis.</td>
<td>5.0</td>
<td>0.00</td>
</tr>
<tr>
<td>1. Studying my course notes enables me to learn organic reactions.</td>
<td>4.0</td>
<td>0.82</td>
</tr>
<tr>
<td>1. Studying the text enables me to learn organic reactions.</td>
<td>3.8</td>
<td>1.50</td>
</tr>
<tr>
<td>1. Studying “paper reaction flash cards” enables me to learn organic reactions.</td>
<td>3.3</td>
<td>0.96</td>
</tr>
<tr>
<td>1. Studying “cell phone reaction flash cards” enables me to learn organic reactions.</td>
<td>4.0</td>
<td>0.82</td>
</tr>
<tr>
<td>1. “Cell phone” based learning tools are valuable because I always have my cell phone with me but I do not always have my computer, texts, notes, and other learning methodologies with me.</td>
<td>5.0</td>
<td>0.00</td>
</tr>
<tr>
<td>1. I am concerned that students might attempt to “cheat” on exams by using their cell phones.</td>
<td>2.0</td>
<td>1.00</td>
</tr>
<tr>
<td>1. I am confident my instructor can prevent student cell phone “cheating” on exams.</td>
<td>4.0</td>
<td>2.00</td>
</tr>
</tbody>
</table>
“...no giant deck of cards to keep track of…”
“...more convenient and more fun to look at than paper cards...”
“...could conveniently review the [cell phone] cards between classes...”
“...who wants to carry pages of paper cards...”
“...study them in the car going to church...”
“...every Wed night when driving to relatives house for dinner...”
“...always have my cell phone with me when I am in the bathroom...”

GGC students also use faculty-generated preparatory videos created using the SmartBoard Airliner wireless tablet, as another tool for effective class preparation. One effective aspect of these videos is that students can pause, rewind or rewatch a certain part of a video as many times as necessary until the material becomes clear. In this way, the videos can be treated as ‘mini-lectures’, thus allowing for the minimization of straight lecture during class time, and the maximization of student-faculty interaction during class. Videos have been crafted for a variety of topics, and screen captures of several types are shown, from nomenclature (Figure 5), electron configurations (Figure 6) reaction mechanisms (Figure 7), and synthetic methods (Figure 8). Typically, many students watch these videos on their computers, but they can also be viewed on cell phones (Figure 9).

The Airliner preparatory videos have also been extremely well received by the students, and it is clear that they have made an impact on the way that the students learn chemistry. The following statements illustrate their positive attitude concerning preparatory videos:

“...the prep videos help me understand the material much more than the book. For visual learners, this is exactly what we need...It makes it easier for students to prep for class and come prepared with questions...”
“…the videos are an excellent aid in my preparation for class….they also allow me to focus on the course objectives, because they summarize what to expect in the lecture and on quizzes…the videos are very convenient – I can access them whenever I need to and can learn at my own pace…”

“I love the videos for several reasons:
1. They are extremely informative, and explain the material better than the textbook.
2. I can view them at any time, like having the professor ‘on call’.
3. I use them as a learning tool. First I watch the video in its entirety, then I watch it again using the ‘pause’ mechanism to see if I can perform the ‘next step’ myself so have an immediate confirmation that I understand the material.”

The Thayer Method in general has proved to be very successful in our general and organic chemistry classes at GGC, particularly in terms of increasing student engagement and activity in the classroom. The general student feeling of the method appears to follow a pattern – initially, many students are intimidated by the highly structured nature of the class, and are even more so about the idea of getting up to the boards and working problems themselves; however, over the course of the semester, many come to appreciate the help that this structure gives them in terms of preparation for each lesson, and really enjoy getting up and being active participants, rather than passive observers, in the class. Table 2 shows some very positive results from end of semester student evaluation Likert scale questions, targeted towards student preparation and class activity.

<table>
<thead>
<tr>
<th>Respond to the statements using the scale below:</th>
<th>Principles</th>
<th>Organic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I was given enough information to be able to prepare for class.</td>
<td>4.8</td>
<td>4</td>
</tr>
<tr>
<td>2. Out-of-class assignments helped me understand concepts.</td>
<td>4.6</td>
<td>.5</td>
</tr>
<tr>
<td>3. Working homework problems before class was important to my learning.</td>
<td>4.3</td>
<td>.9</td>
</tr>
<tr>
<td>4. Viewing mini-lectures before class was important to my learning.</td>
<td>3.8</td>
<td>1</td>
</tr>
<tr>
<td>5. Viewing cell phone flashcards before class was important to my learning.</td>
<td>2.5</td>
<td>1</td>
</tr>
<tr>
<td>6. Time in class helped me understand the concepts covered in this course.</td>
<td>4.7</td>
<td>.5</td>
</tr>
<tr>
<td>7. The instructor encouraged class discussion, participation, or questions.</td>
<td>4.8</td>
<td>.3</td>
</tr>
<tr>
<td>8. Instructor/student discussion &amp; Q/A in class was important to my learning.</td>
<td>4.7</td>
<td>.6</td>
</tr>
<tr>
<td>9. Working individually at whiteboards was important to my learning.</td>
<td>3.9</td>
<td>1</td>
</tr>
<tr>
<td>10. Working in groups at whiteboards was important to my learning.</td>
<td>4.5</td>
<td>.8</td>
</tr>
<tr>
<td>11. Regular quizzes in class were important to me learning course material.</td>
<td>4.0</td>
<td>1</td>
</tr>
<tr>
<td>12. Whiteboards improved my ability to work w/classmates orally &amp; in writing.</td>
<td>4.3</td>
<td>.8</td>
</tr>
<tr>
<td>13. By semester end, I was comfortable/confident working at whiteboards.</td>
<td>4.4</td>
<td>.8</td>
</tr>
</tbody>
</table>

Of particular note from the survey results is the fact that each of the following was clearly helpful to student learning, and providing some indication of successful use of the Thayer Method:

- Group use of the whiteboards in class.
- Faculty – student Q & A sessions in class.
- Viewing the preparatory videos (particularly in organic chemistry).
- Working homework problems before class.

The following statements, from both general and organic chemistry students, illustrate their positive attitudes to the Thayer Method:

“The whiteboards were the most important part of the learning experience for me in this class. Working alongside peers and having to think critically was vital for me to comprehend and retain the material. It basically made chemistry, a difficult topic, easy.”

“I liked the fact that you were supposed to teach yourself ahead of time and come to class to ask questions.”

“The mini-lectures on webct were extremely helpful. Being a transfer student, I noticed a huge increase in retention of the course material.”

“The teaching method, though different than what I am accustomed to, was preferable to former methods!!!!!”

“Use of technology was vital to my understanding of the course material. I couldn’t imagine the semester without it…”
CONCLUSION

With the positive initial reception of cell phone flash cards, Airliner preparatory videos and the use of the Thayer method in general, the plan will be to adopt their use across other chemistry courses when they are offered at GGC.

It is clear that, although the Thayer Method is not a teaching method that many students have seen before they come to GGC, the overall opinion of the method has been overwhelmingly positive. Many students respond very well to a highly structured class format, as they feel that it allows them to study much more effectively for each class, rather than coming into a class (without any preparation) and having no clue as to what will be covered that day.

Students have also indicated their approval of the airliner videos and, to some extent at least, the cell phone flash cards. The major current disadvantage to the use of the flash cards at GGC is that only a very limited number of students have sufficiently smart phones to be able to view the flash cards. Faculty at GGC have been working to circumvent this problem, and recently were awarded internal funding from GGC to allow for two complete sections of organic chemistry students to receive smart phones to use throughout the semester.

The expanded study will include attitudinal surveys of students and faculty and also investigate how performance on graded events covering topics such as organic reactions might be related to student cell phone flash card use. How student use of cell phone flash cards is impacted by this funding, as well as an assessment of how effective the cell phone flash cards prove to be, will be reported in a future communication.

REFERENCES


