Leveraging Technology-based Instructional Material with Group Problem-Solving to Flip the Organic Chemistry Curriculum

Fall 2021 - Spring 2022

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September 19, 2022

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ABSTRACT

Within the past decade there is growing evidence for the efficacy of the flipped learning model in helping students succeed in science, technology, engineering and math (STEM) courses. Flipped learning describes a pedagogy that reverses the order in which students interact with the subject material: the traditional in-person didactic lecture is delivered to the students before coming to class, while class time is reserved for homework-like activities in an active learning environment. The goal of this sabbatical project is to use technology-based instructional material to implement the flipped learning model for Chemistry 80, the first semester of the year-long sequence of organic chemistry. To accomplish this goal, the project includes an independent study of the flipped learning pedagogy and development of the following instructional materials: 1) video lectures to be hosted on YouTube, 2) PlayPosit modules to monitor student viewing, and 3) worksheets and quizzes for in-class engagement. The flipped learning model has the potential to help Mt. San Antonio College students succeed in this first sequence of second-year chemistry.

STATEMENT OF PURPOSE

With recent development in technology, flipped learning has emerged in the last decade as an attractive alternative teaching method to the traditional college lecture. Flipped learning consists of two principles: 1) fundamental information is delivered through pre-class materials and 2) the in-class setting is used to apply or elaborate the content through active learning. Before the boom in technology that allows for the ease of video recording and hosting, the first component of the flipped model was limited to publisher's multi-media material, ranging from the textbook to PowerPoint slides to a rare short video presentation. Now, individual instructors can give students tailor-made videos that not only match the caliber of an in-class lecture but surpass it with features that are not possible in time-constrained class setting, like pausing or rewinding a lecture.

This mode of teaching and learning is especially valuable in STEM courses where the material load is heavy with theories and applications. The value of flipped learning is principally attributed to its emphasis on active learning, an education approach that has been shown to improve performance of students in undergraduate STEM courses, and especially for those students with diverse learning styles and preparedness (1). Active learning is especially effective in reducing the achievement gaps for students from underrepresented groups (2); an important finding as underrepresented minority students is the majority of the student population served at Mt. San Antonio College (Mt. SAC). As an active learning pedagogical approach, flipped learning in particular, has also been shown to be an effective tool across disciplines and education levels (3), and particularly in Chemistry (4, 5, 6).

The purpose of this project is to apply the flipped learning model to Organic Chemistry 1 (Chemistry 80), which is the first course in a 2-semester sequence in second-year college chemistry. Organic chemistry as a whole is notorious for being one of the most difficult subjects in the undergraduate curriculum (7) and one that all students majoring in chemistry, biology and pre-medical sciences (e.g. optometry, dentistry, pharmacy and medicine) need to pass. Students approach the class with much trepidation and often find the pace of the class too fast (8). This may be attributed to the abstract nature of organic chemistry (for example students need to grasp the skill of relating 3-dimensional structures to their 2-dimensional representations in order to determine functionality and reactivity) and the large quantity and complexity of chemical reactions that is covered (9). Thus, success in organic chemistry requires not only constant practice from the students, but the close guidance of the instructor to help students apply the concepts, build confidence and gain mastery (10). With much to cover in a semester, the instructor in a traditional classroom spends a vast majority of the time in class introducing the material, leaving students to struggle with the homework outside of class, often alone. One way to slow down the pace of the class is to leverage technology to push the lecture component prior to students coming to class. With the lecture delivered via videos at home, students can pause or rewind, literally slowing down the pace of the class, minimizing the cognitive load and accommodating different learning styles. The class time now is more student-centered as the instructor is removed from the podium and directly interacting with students and providing timely feedback.

SABBATICAL PROJECT NARRATIVE

To achieve the purpose of this Sabbatical Project, of applying the flipped learning model to Chemistry 80, I envisioned devoted my time to the following activities:

1. Independent study of the leading literature on the flipped learning methodology
2. Production of lecture videos for Chemistry 80
3. Creation of auxiliary educational material for Chemistry 80
4. Conference participation in flipped learning community

Activity 1 – Independent study of the leading literature on the flipped learning methodology. I started my sabbatical with looking at the literature discussing the efficacy and methodology of flipped learning, including best practices for its implementation in organic chemistry. Much of my research was spent in the early weeks of my sabbatical but was also sustained throughout the rest of the project. I used the knowledge gained from my independent study in guiding the design of the videos and auxiliary educational material, both of which are the paramount components of the project.

For example, I decided to pay more attention to the way I craft my video lecture and its presentation as Casselman *et al.* suggests that the online pre-class activities have a significant contribution to students' improved course performance (11). Their research shows how it is not only the in-class interactions that help students achieve but that a well-crafted pre-class activity, like video lectures with engagement points offered by the PlayPosit platform (discussed in the next section), is crucial to the success of the flipped classroom. As for the in-class best-practices, Naibert *et al.* concluded that when students were expected to spend a larger percentage of in-class working in a group instead of participating in Socratic dialogue with the instructor, more of the students reported watching all of the videos (12). With this finding, I have designed the in-class auxiliary education material to be worksheets where students can work together in groups akin to Process Oriented Inquiry Learning (POGIL) based activity. Another best-practice recommended by Christiansen *et al*, was to have in-class quizzes as take-home quizzes as take-home quizzes demotivated attendance and preclass watching of the videos in a flipped classroom (13). With this finding I was encouraged to use low-stakes, frequent testing within the classroom setting, which is now more available as class time is more available in the flipped learning environment.

In addition to updating my knowledge by surveying peer-reviewed research manuscripts from such established journals like American Chemical Society's Journal of Chemical Education, I also read the earliest book on the flipped methodology: *Flip Your Classroom – Reach Every Student in Every Class Every Day* by Jonathan Bergmann and Aaron Sams (14). Using this book as a guide, I reflected on my own experiences with the flipped learning approach, its successes and shortcomings in order to make concrete adjustments in my application of the theory in my own classroom. From this book, my key take-away of why an instructor would want to flip their classroom are:

- Today's students are tech-natives, so this speaks their language
- Students are busy and appreciate the flexibility
- Accommodates students learning at different speeds and preparedness
- Increase teacher-student interactions, teachers can know their students better
- Increase student-student interactions, building a learning community
- Provide a platform for active learning

Activity 2 – Production of lecture videos for Chemistry 80. As stated in my proposal, the Natural Science division purchased the Lightboard technology, now physically housed in Professional & Organizational Development, that would have allowed instructors to present a lesson by writing on the ultra-clear LED board while at the same time maintaining eye-contact and gesture visibility. This technology was scheduled to be available in the Fall of 2021, the beginning of my sabbatical. Unfortunately, due to circumstances related to the COVID-19 pandemic, the Lightboard was not available when I started my project. I had to quickly pivot and find an alternative method to record the lecture. After trying various software suites, including Screencast-o-matic and Camtasia, I concluded that capturing the screen in video mode while using the Whiteboard feature on Zoom in combination with iPhone recordings of myself introducing the topics allowed for the most ease in the production process without sacrificing the quality and feel of a lecture in the classroom that I was aiming for. The post-production process remained as proposed with the use of iMovie for video editing and YouTube as the video host.

My original goal was to produce videos for fourteen chapters from Organic Chemistry by David Klein, the official adopted textbook of Chemistry 80, with each chapter having two to four lessons. Although the video for each lesson may only be 20-40 minutes in length, the time to produce each was often 10-fold or more. Consequently, by the end of my sabbatical I was only able to cover seven chapters, with a total of 16 videos on YouTube and 2 videos yet to be posted. Even with my experience in making videos for Chemistry 10 prior to this sabbatical, I quickly discovered it took much more time and effort to make videos for Chemistry 80, a much more advanced course. However, the 18 videos completed will be the catalyst for me to complete the rest of the videos upon my return as I have now established the framework and rhythm in the project.

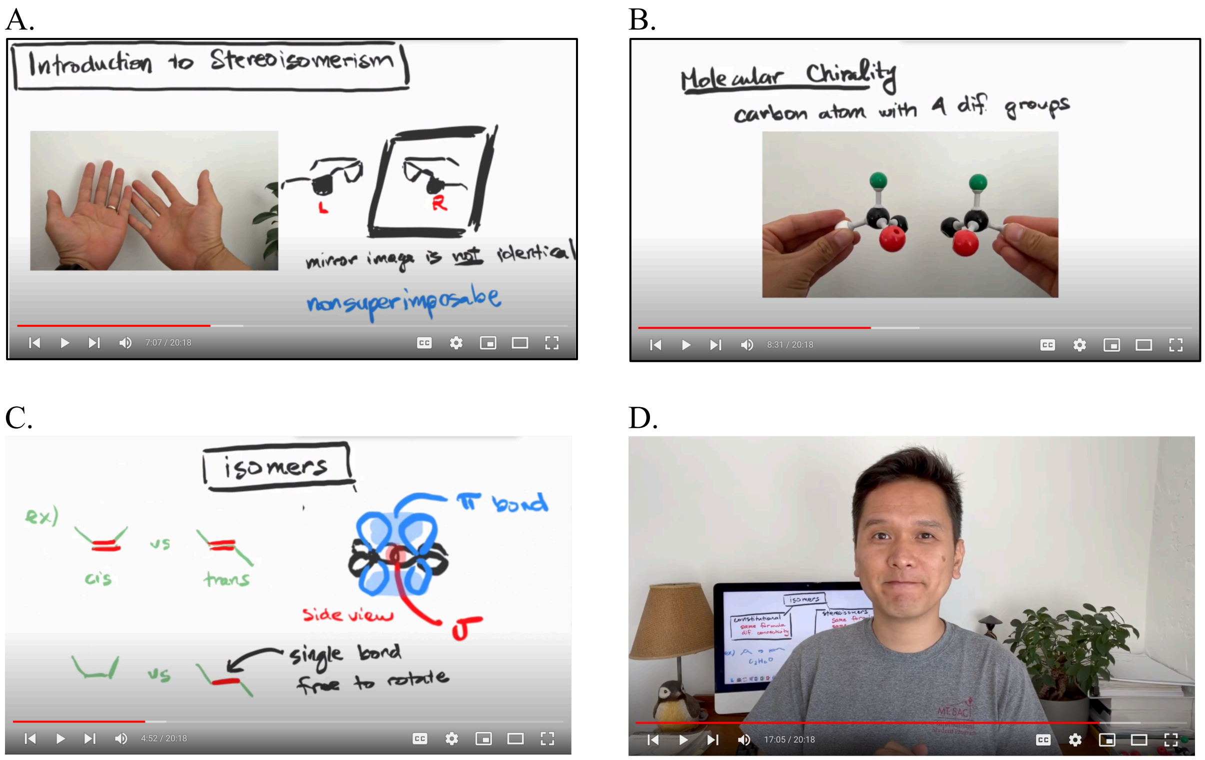

Figure 1 Features of Videos. Screenshots of "Lec 10 Introduction to Stereoisomerism, Chirality and Fischer Projection | Chapter 5 (Part 1 of 3)" hosted on YouTube to illustrate features of a typical lecture video. **A.** Screen-in-screen mode allows for students to have enhanced visual experience of the video lecture, in this case I am showing how my hands are example of chiral objects in everyday life. **B.** Another screen-in-screen mode example allows students to have an experience similar to an in-class lecture where I would show molecular models of two chiral molecules. **C.** Using Zoom Whiteboard features I have access to multicolor presentations. **D.** To make the videos more engaging and inviting, I recorded myself speaking during introductions and transitions of topics.

Activity 3 – Creation of auxiliary educational material for Chemistry 80. PlayPosit is an online educational platform that allows instructors to host video lessons with different active learning features, ranging from pause-and-reflect with essay-type responses to multiple-choice questions. Not only does this platform allow for the instructor to know which students are watching the video lessons but also allow the instructor to have a glimpse into the understanding level of the students. As part of the design process of the PlayPosit assignments, I watched the final-cut of each video lesson to craft interactions that reviews and connects concepts, promotes critical thinking and/or check new concept understanding.

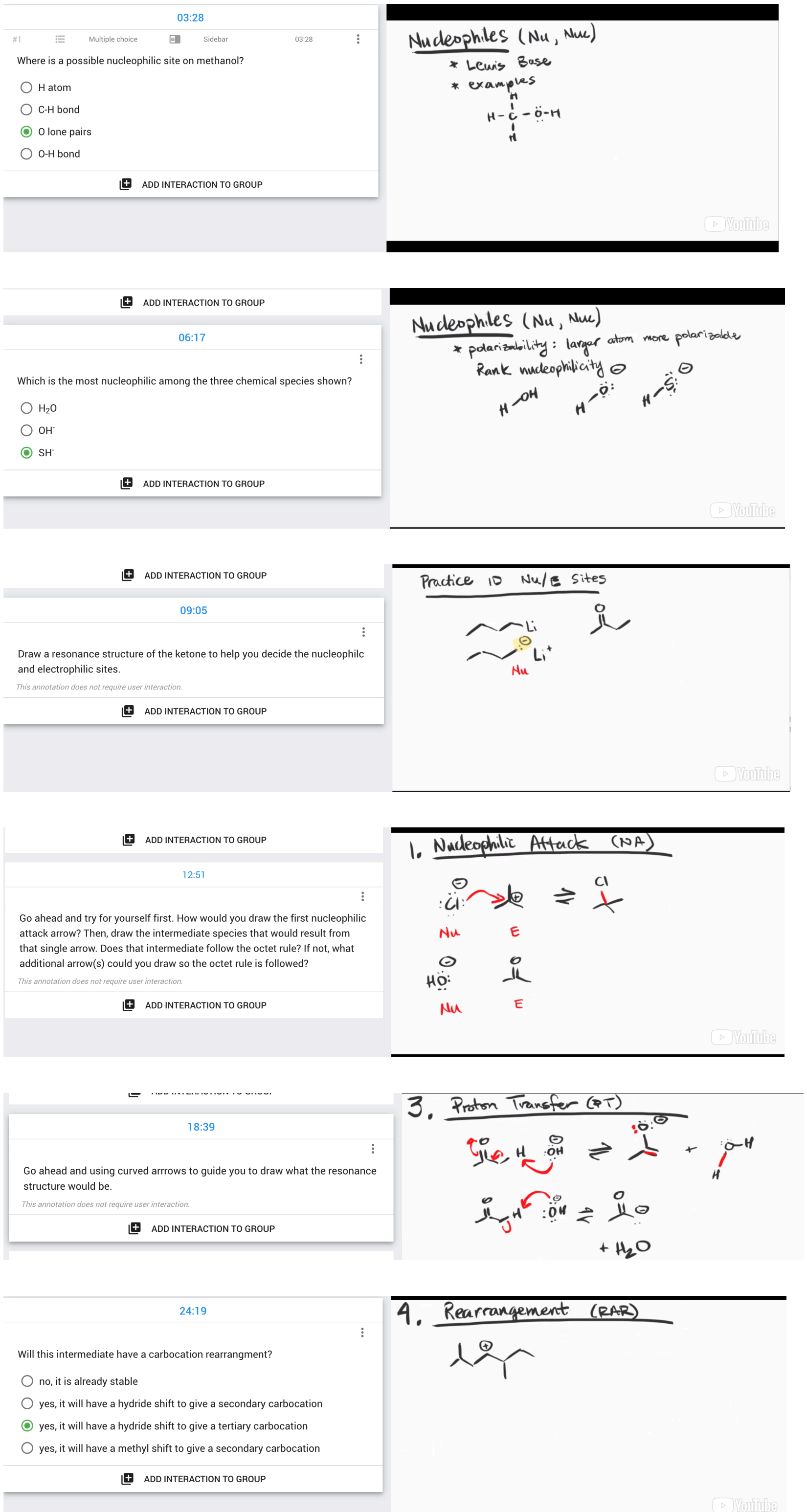

Figure 2 Example of PlayPosit Engagement. Screenshots of the PlayPosit interactions used for video "Lec 13 Intro to Mechanisms | Chapter 6 (Part 1 of 1)". With a length of 31 minutes, there are 6 interactions (time stamp in blue) including multiple-choice and free-response type questions. Students can rewind to review the material before answering the questions. This is also an example of frequent, low-stakes quizzing.

The last component to the flipped learning model is the valuable class time. This is the time for students to struggle more with the material, but in the flipped learning environment they have the added benefit of discussions with their peers and the guidance of the instructor. I crafted Lecture Activities for each lesson with problems directly related to the video lectures (see Appendix I for example). The Lecture Activities also include problems that are traditionally "homework" problems and will be derived from the Course Measurable Objective to help students direct their attention to the most important skills and concepts covered. I have also designed the Lecture Activities to follow the POGIL methodology with guiding questions to facilitate discussions among students working in small groups.

Additionally, each lesson will be followed by a quiz to check for understanding (see Appendix II for example). I have written the quiz to include free response and multiple-choice questions. This frequent testing technique has been shown to help students learn and reduce the achievement gaps as it requires students to practice retrieving and reconstructing knowledge as part of what researchers call deep learning (16, 17). Along with the videos, these auxiliary educational materials will be shared with colleagues teaching Chemistry 80, whether they decide to adopt the flipped learning pedagogy in full or in part.

Activity 4 – Conference participation in flipped learning community. The last component of my independent study and project was supposed to be attendance and participation of premiere conferences in chemical education. My aim was to attend two national meetings. The first is to attend the 27th Biennial 2-Year College Chemistry Consortium (2YC3) conference hosted by ACS which focuses entirely on chemistry education at 2-year institutions and the success of community college students in chemistry. The second conference was supposed to be the Gordon Research Conference on Chemistry Education Research and Practice, where leaders at the frontiers of disciplined-based education research will share their latest findings in chemical education. Unfortunately, due to my concerns of traveling during the pandemic and COVID-19 related cancellations I was not able to attend these in-person conferences.

As an alternate activity I participated in an online pedagogy conference hosted by the Teaching Experiment Academy called "2022 TEA Summit" (See Appendix III). In this conference a team of STEM professors from UC Irvine, San Jose State University and Cal Poly Pomona presented their work in redesigning the STEM curriculum with an emphasis on mastery learning and specification grading – the key feature of which is for students to be graded based on their mastery of the topics taught in class rather than just passing with points. Although this conference was not directly related to flipped learning, these learning structures fits well with the active learning approach of the flipped classroom. From this conference I was able to reflect on how I can adopt some features of mastery learning and specification grading into my class. For example, instead of a final exam for the lab I can assign students a presentation project where they make a video demonstrating how to perform a particular lab technique. This video will also be useful, with student consent, as a teaching tool as future students can watch the video to preview the techniques.

SABBATICAL PROJECT ACTIVITY TIMELINE

Fall Semester 2021

Week of	**Description of Activity**
August 23	**Independent study** *Flip Your Classroom: Reach Every Student in Every Class Every Day* by Jonathan Bergmann and Aaron Sams (2012)
August 30	**Technology Research and Prototype** Zoom screen capturing iPhone filming iMovie film editing
September 6	**Ch. 1 A Review of General Chemistry** Preparing notes, writing scripts and recording lecture Auxiliary material
September 13	Post-production editing Part 1
September 20	Post-production editing Part 2
September 27	**Ch. 2 Molecular Representations** Preparing notes, writing scripts and recording lecture Auxiliary material
October 4	Post-production editing Part 1
October 11	Post-production editing Part 2
October 18	**Ch. 3 Acids and Bases** Preparing notes, writing scripts and recording lecture Auxiliary material
October 25	Post-production editing Part 1
November 1	Post-production editing Part 2
November 8	**Ch. 4 Alkanes and Cycloalkanes** Preparing notes, writing scripts and recording lecture Auxiliary material
November 15	Post-production editing Part 1
November 22	Post-production editing Part 2
November 29	Post-production editing Part 3
December 6	Review and Reflect on First 9 Videos

Spring Semester 2022

Week of	Description of Activity
February 28	**Ch. 5 Stereoisomerism** Preparing notes, writing scripts and recording lecture Auxiliary material
March 7	Post-production editing Part 1
March 14	Post-production editing Part 2
March 21	Post-production editing Part 3
March 28	**Ch. 6 Introduction to Mechanisms** Preparing notes, writing scripts and recording lecture Auxiliary material
April 4	Post-production editing
April 11	**Ch. 7 Alkyl Halides Part 1** Preparing notes, writing scripts and recording lecture Auxiliary material
April 18	Post-production editing Part 1
April 25	Teaching Experiment Academy Conference "2022 TEA Summit"
May 2	**Ch. 7 Alkyl Halides Part 1** Post-production editing Part 2
May 9	Post-production editing Part 3
May 16	**Ch. 7 Alkyl Halides Part 2** Preparing notes, writing scripts and recording lecture Auxiliary material
May 23	Post-production editing Part 4 (not uploaded)
May 30	Post-production editing Part 5 (not uploaded)
June 6	Writing Sabbatical Report
June 13	Writing Sabbatical Report

SABBATICAL PROJECT – THE "PRODUCT"

List of Titles of YouTube Videos, their Links and Lengths in Min:Sec

1. Lec 1 Bonding and Lewis Structure | Chapter 1 (Part 1 of 2)
    a. https://youtu.be/NiuH9m_SAis
    b. 19:06

2. Lec 2 Covalent Bonding Theories | Chapter 1 (Part 2 of 2)
    a. https://youtu.be/drCezfLKVVc
    b. 17:16

3. Lec 3 Bond Line Structure and Functional Groups | Chapter 2 (Part 1 of 2)
    a. https://youtu.be/v6O8t2eku50
    b. 15:34

4. Lec 4 Resonance and Curve Arrows | Chapter 2 (Part 2 of 2)
    a. https://youtu.be/GkxcNq381DU
    b. 25:05

5. Lec 5 Acid Base Definitions, pKa and Leveling Effect | Chapter 3 (Part 1 of 2)
    a. https://youtu.be/RFLTnO-IxTE
    b. 29:15

6. Lec 6 Comparing Acid Strengths Using ARIO | Chapter 3 (Part 2 of 2)
    a. https://youtu.be/NRXc253mzZE
    b. 20:57

7. Lec 7 Alkane Nomenclature | Chapter 4 (Part 1 of 3)
    a. https://youtu.be/pd04aGJhX6w
    b. 22:13

8. Lec 8 Linear Alkane Conformational Analysis | Chapter 4 (Part 2 of 3)
    a. https://youtu.be/fb6nOMR6ZWI
    b. 17:43

9. Lec 9 Cycloalkane Conformation Analysis | Chapter 4 (Part 3 of 3)
    a. https://youtu.be/R49V31Kq5AE
    b. 22:11

10. Lec 10 Introduction to Stereoisomerism, Chirality and Fischer Projection | Chapter 5 (Part 1 of 3)
    a. https://youtu.be/NaDFmLRTf3Y
    b. 20:19

11. Lec 11 Designating Configuration Cahn Ingold Prelog System | Chapter 5 (Part 2 of 3)
   a. https://youtu.be/YhUvKm7xNCc
   b. 22:21

12. Lec 12 Enantiomers, Diastereomers, Meso Compounds and Optical Activity | Chapter 5 (Part 3 of 3)
   a. https://youtu.be/qEXQDJVUFmY
   b. 28:41

13. Lec 13 Intro to Mechanisms | Chapter 6 (Part 1 of 1)
   a. https://youtu.be/h-57JGBcxZ8
   b. 31:31

14. Lec 14 Intro Substitution/Elimination; Alkyl Halide & Alkene Nomenclature | Chapter 7 (Part 1 of 5)
   a. https://youtu.be/QrbO3F-dV6g
   b. 25:49

15. Lec 15 SN2 Reactions | Chapter 7 (Part 2 of 5)
   a. https://youtu.be/4uMAvd5qvpk
   b. 6:56

16. Lec 16 E2 Reactions | Chapter 7 (Part 3 of 5)
   a. https://youtu.be/4jjwW76EDjg
   b. 34:21

CONCLUSION

Professional Growth and Enrichment. My doctoral training was in protein chemistry. Besides from the teaching assistant assignment as a graduate student, admittedly I had little formal training in the art of teaching itself. As a professor at Mt. SAC, my teaching philosophy was molded with every semester, tweaking my teaching practices with every iteration of a class. I was learning a lot on the job, whether that be through self-reflection, sharing with colleagues or attending teaching conferences. And for the most part I was able to apply those lessons and best practices. However, when it came to the flipped learning methodology, it was too big of a transformation to accomplish with the seemingly constant responsibility of everyday work. I would have a goal to do a few videos but before the camera was rolling it was already the end of another semester.

This sabbatical was exactly what I needed to start on this journey of transforming one of the most challenging courses that I teach. Despite not completing an entire semester of videos, I have confidence that what I have accomplished during my sabbatical will catapult me to the end – just starting the project was one of the biggest activation barriers; and now that I have a framework and rhythm the remainder videos seem surmountable. Ultimately, the experience and the fruit of my sabbatical have expanded my knowledge in the field of chemical education, satisfied my goal of initiating the process of flipping Chemistry 80, and revitalized my excitement as I plan to implement the changes in my class upon my return.

Benefits and Value to the College. Anecdotally, Chemistry 80 is notorious among STEM students as one of the toughest classes at Mt. SAC. But Mt. SAC students are not alone in this sentiment (10). The main purpose of this sabbatical project was to tackle this issue by transforming the way organic chemistry is delivered to students that has been shown to improve student learning outcomes (15). By making the videos and auxiliary learning material I can implement the flipped learning methodology to Chemistry 80 in my own classroom, and share it with colleagues who can adopt this active learning approach. This transformation will provide a more inclusive learning environment to the student population, supporting all students in achieving their education goals. As Mt. SAC strives to be regarded as a premier community college in the nation, it is fitting that its faculty and curriculum is at the forefront in our teaching, blazing trails in our exploration to support student success. By implementing the flipped learning pedagogy, the chemistry department as a whole, and I myself on a more individual basis, will be contributing to this mission.

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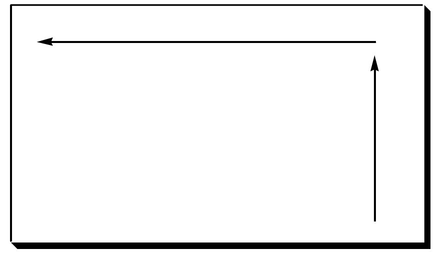
Lecture Activity 6 – Lec 6 Comparing Acid Strengths Using ARIO | Chapter 3 (Part 2 of 2)

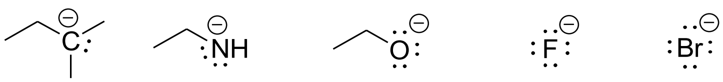
Factors that govern relative acid strength: ARIO (Atom, Resonance, Induction, Orbital)

A. Element Effects – atoms to the right and bottom on the periodic table can better stabilize a base, making it a weak base.



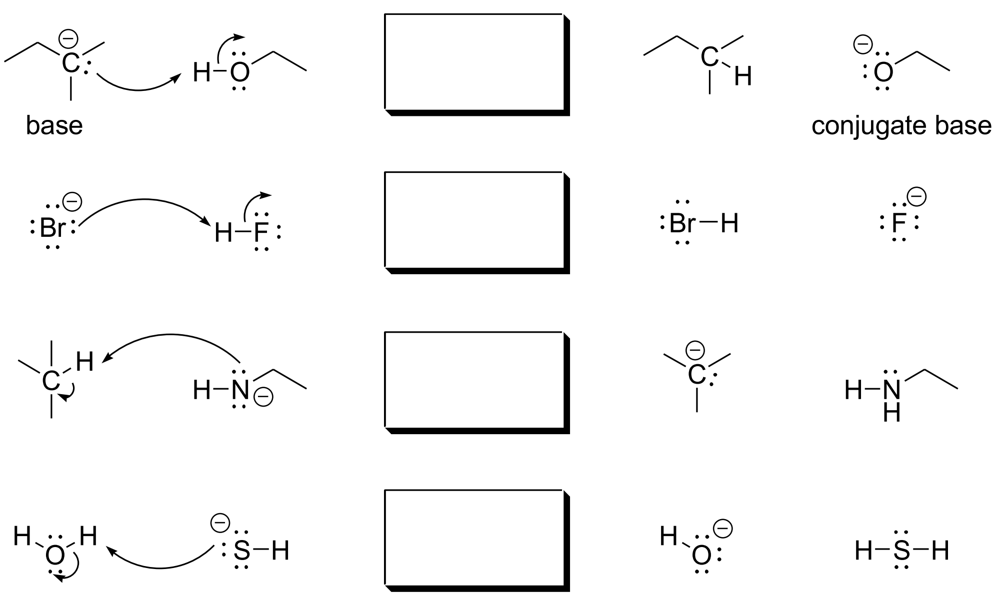
INCREASING BASE STRENGTH ON PERIODIC TABLE

1. Rank the following, in order of increasing base strength with 1 being the strongest base.



2. Draw the conjugate acid of the bases in the previous problem #1. Rank the acids in the order of increasing acidity with 1 being the strongest acid. Recall strong acids, produce weak conjugate bases and vice versa.

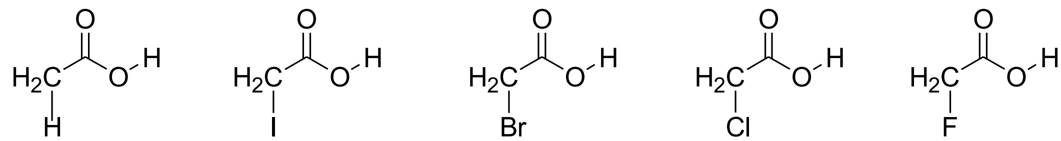
3. With respect to the relative base strength in the previous problem #1, predict the position of equilibrium in the following reactions as written.



Summary: Equilibrium lies toward the more stable, weaker base Identify the base and conjugate base, and equilibrium favors the atom that is more towards the right and bottom on the periodic table.

B. Inductive Effects – electron withdrawing atoms or electron withdrawing groups (EWG) can better stabilize a base, making it a weak base. Typical EWGs include: –X (halogens), C=O, NO_2, SO_3R, CN, and NR_3^+.

4. Draw the structure of the conjugate base of the following acids:



pK_a	4.76	3.13	2.86	2.81	2.66

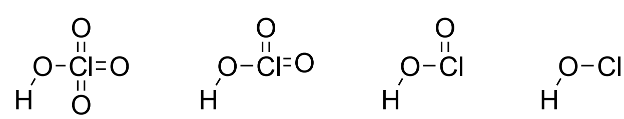
5. What is structurally similar between the conjugate bases in #4?

6. What is structurally different between the conjugate bases in #4?

7. Based on the provided pK_a values, rank the conjugate bases of the above acids in the order of increasing basicity with 1 being the strongest base.

8. Does having electron withdrawing groups (EWGs) weaken or strengthen the base?

9. Draw the structure of the conjugate base of the following oxyacids:

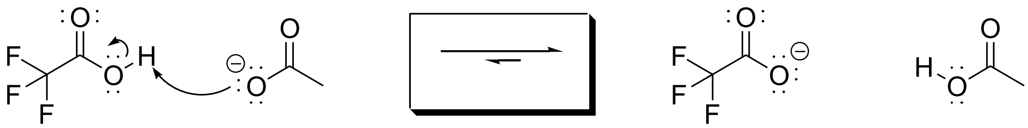


pK_a	-10	0	1.96	7.54

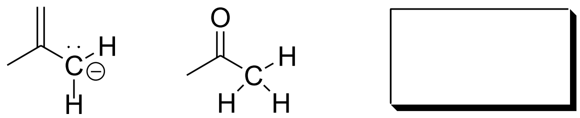
Structure of conjugate base:

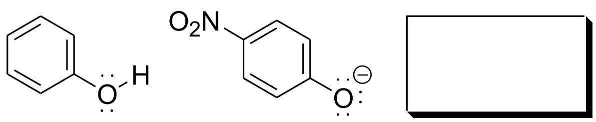
10. Based on the provided pK_a values, rank the conjugate bases of the above oxyacids in the order of increasing basicity with 1 being the strongest base.

11. Use curved arrows to depict the following acid-base reaction, and predict the product. In the empty box, predict if the equilibrium of the reaction will lie to the left or to the right as drawn. The first example has been completed as a reference.



base conjugate base

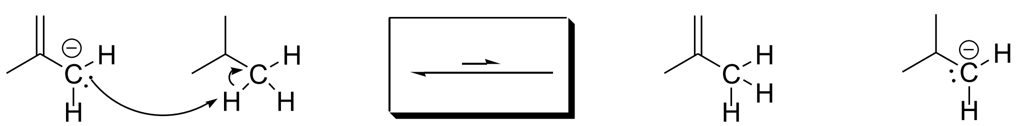




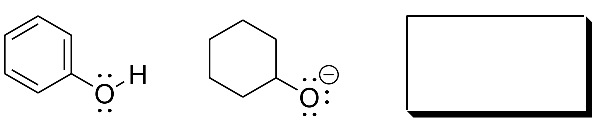
Summary: Equilibrium lies toward the base with more inductively withdrawing atoms/groups Identify the base and conjugate base, and equilibrium favors the base with more EWGs

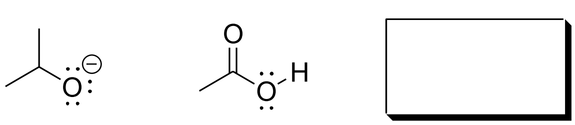
C. Resonance Effects – resonance structures can better stabilize a base, making it a weak base.

12. Use curved arrows to depict the following acid-base reaction, and predict the product. In the empty box, predict if the equilibrium of the reaction will lie to the left or to the right as drawn. The first example has been completed as a reference.



base conjugate base

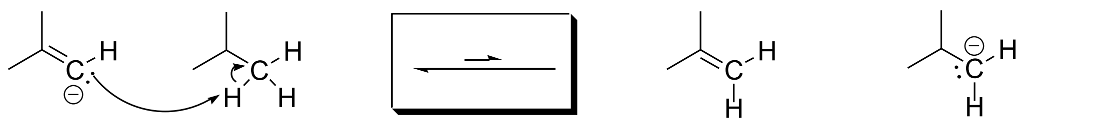




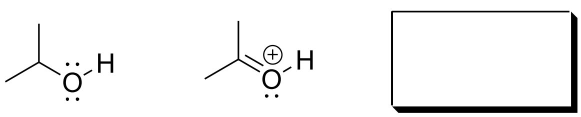
Summary: Equilibrium lies toward the base with possible resonance structures Identify the base and conjugate base, and equilibrium favors the base with resonance capabilities.

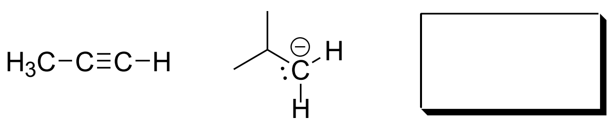
D. Hybridization Effects – *s* orbitals can better stabilize a base than a *p* orbital, making it a weaker base because *s* orbitals are more electronegative than *p* orbitals.

13. Use curved arrows to depict the following acid-base reaction, and predict the product. In the empty box, predict if the equilibrium of the reaction will lie to the left or to the right as drawn. The first example has been completed as a reference.



base - sp^2 C   conjugate base - sp^3 C





Summary: Equilibrium lies toward the base with sp > sp^2 > sp^3 hybridization Identify the base and conjugate base, and equilibrium favors the base with sp > sp^2 > sp^3 hybridization.

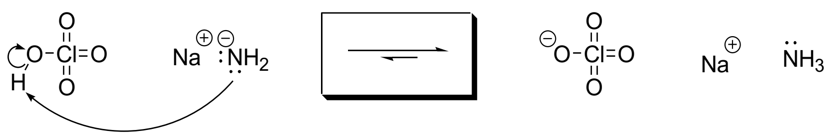
Using ARIO – Mnemonic device that shows the order of priority among the 4 effects

Summary. Identify the base and conjugate base. Equilibrium favors:

A – base to the right and bottom on periodic table
R – base with resonance structures
I – base with EWGs
O – base with sp > sp^2 > sp^3 hybridization

---

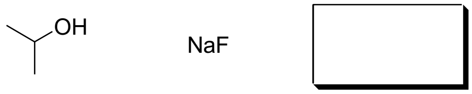
14. Draw the product of the following acid base reaction. Predict the position of equilibrium using ARIO. The first example has been completed as a reference.



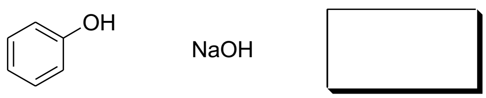
base

conjugate base

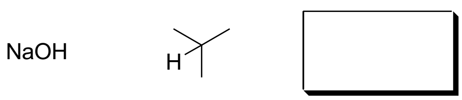
A ⟶ O is more to the right
R ⟶ conj. base has resonance structures
I ⟶ conj. base has EWGs
O ⟶ conj. base is sp^2 hybridized



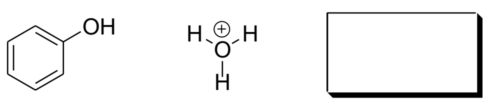
A
R
I
O



A
R
I
O



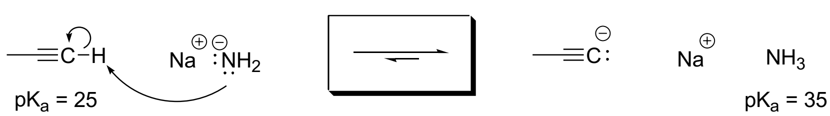
A
R
I
O



A
R
I
O

---

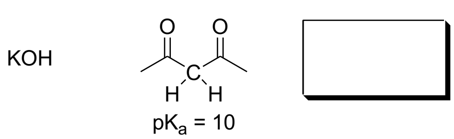
15. Caveat. ARIO is a general guideline. Sometimes wrong predictions can be made. Using pK_a values, show how the equilibrium prediction from ARIO may be wrong in the following cases. An example has been completed as a reference.



base

conjugate base

A ⟵ N is more to the right
R ✕ neither have resonance
I ✕ neither have EWGs
O ⟶ conj. base is sp hybridized



A
R
I
O

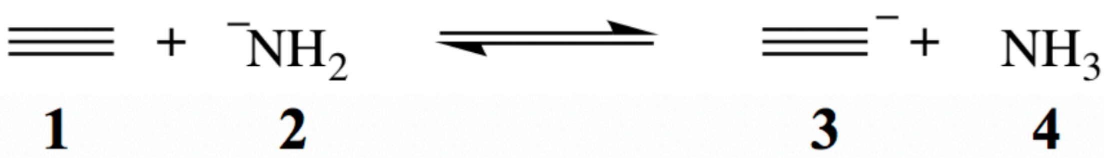
Example of Weekly Quiz

The following quiz is an example of a weekly quiz that adheres to the principle of frequent, low-stakes testing. The quiz is created on Canvas.

Quiz Week 2 (Ch3)

Question 1 — **2 pts**

Consider the reaction as written below. Identify which molecule is the conjugate acid.

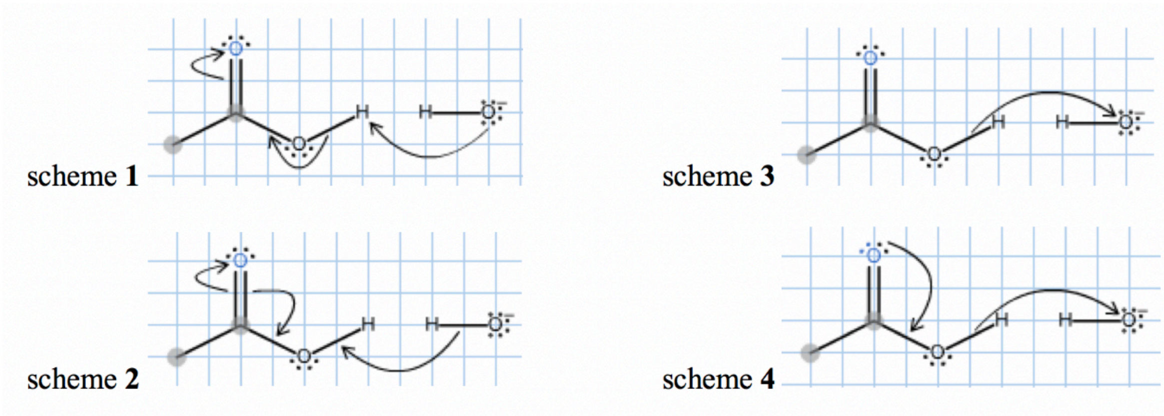


- ○ 1
- ○ 2
- ○ 4
- ○ 3

Question 2

2 pts

Which scheme below shows a plausible arrow-pushing mechanism (curved-arrow notation) for the reaction between carboxylic acid and hydroxide base?



- ○ scheme 4
- ○ scheme 2
- ○ scheme 3
- ○ scheme 1

Question 3

3 pts

3-part question. Provided the two reactants below, will the equilibrium constant, *K*, be smaller or greater than 1? Will the reaction lie to the reactant or product side? Using ARIO, which factor best explains this prediction?

Prediction for K: [Select]

Position of equilibrium: [Select]

Best reason: [Select]

Question 4

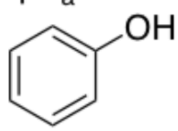
3 pts

Using the pK_a values provided, fill in the blanks.

[Select] is the more acidic molecule.

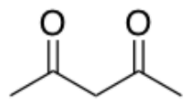
[Select] is the more basic anion.

pK_a = 9.9

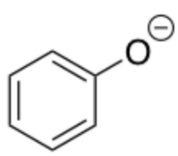


molecule 1

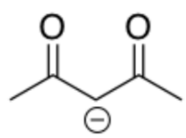
pK_a = 9.0



molecule 2



anion 1

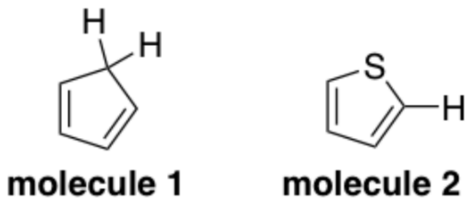


anion 2

Question 5

3 pts

Consider the following two molecules and the protons of interest from each and fill in the blank.



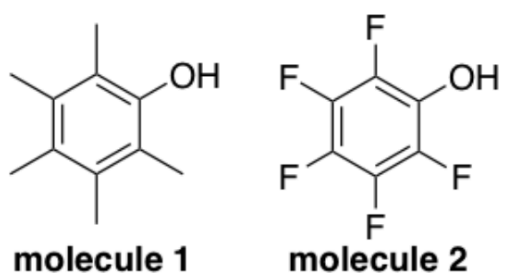
1. Molecule [Select] has the more acidic proton.

2. The best reasoning for this prediction is based on the following ARIO factor: [Select] .

Question 6

3 pts

Consider the following two molecules and the protons of interest from each and fill in the blank.



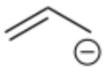
1. Molecule [Select] has the more acidic proton.

2. The best reasoning for this prediction is based on the following ARIO factor: [Select] .

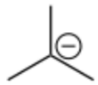
Question 7

3 pts

Consider the following two anions and fill in the blank.



anion 1



anion 2

1. Anion [Select] is more basic.

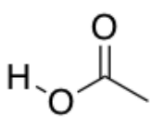
2. The best reasoning for this prediction is based on the following ARIO guideline:

[Select] .

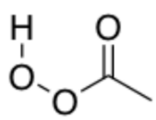
Question 8

3 pts

Consider the following two molecules and the protons of interest from each and fill in the blank.



molecule 1



molecule 2

1. Molecule [Select] has the more acidic proton.

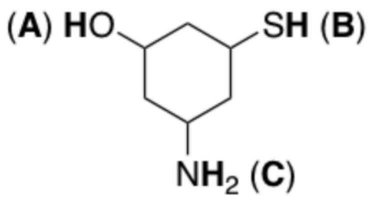
2. The best reasoning for this prediction is based on the following ARIO guideline:

[Select] .

Question 9

3 pts

Consider the following molecule with labeled protons. Rank the acidity of the protons from most acidic (designate as 1) to least (designate as 3). Provide brief reasoning for your choice.



Edit View Insert Format Tools Table

12pt Paragraph B I U A T²

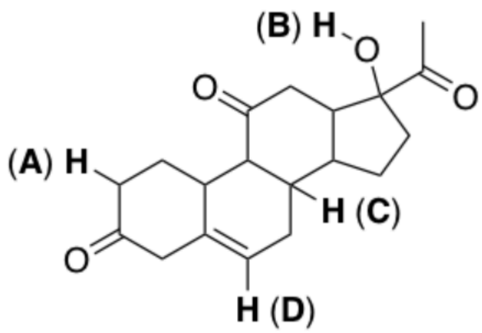
p

0 words </>

Question 10

3 pts

Rank the indicated hydrogens starting with 1 being the most likely to be abstracted (deprotonated) when this molecule is reacted with a strong base and 4 being the least likely. Using ARIO, provide rationales for your ranking system (i.e. explain why you would rank one above the other).



Edit View Insert Format Tools Table

12pt Paragraph B I U A T²

p

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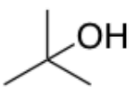
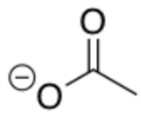
Question 11

2 pts

Which molecule(s) (1, 2, 3 or 4) is strong enough to deprotonate the target alcohol molecule with pK_a = 18?

	NH_3		H_3O^+	$^{\ominus}NH_2$
$pK_a = 18$	**1**	**2**	**3**	**4**

- ○ both 1 and 4
- ○ only 4
- ○ both 2 and 3
- ○ only 3

END OF QUIZ

TEA TEACHING EXPERIMENT ACADEMY

2022 TEA SUMMIT

*Thirty-five STEM faculty from UC Irvine, San Jose State University, and Cal Poly Pomona will demonstrate how **mastery learning** & **specifications grading** boost students' **growth mindset** and enhance their learning experience in the Teaching Experiment Academy (TEA) summit.*

VISIT THE TEA SUMMIT WEBSITE

WHEN:

APRIL 28 - 29, 2022

10AM - 2PM PT

WHERE:

ONLINE

REGISTRATION REQUIRED

REGISTER:

SCAN OR CLICK TO REGISTER

KEYNOTE SPEAKERS:

RENÉE LINK
Professor of Teaching
Department of Chemistry
UC Irvine

ROBERT TALBERT
Professor
Department of Mathematics
Grand Valley State University

UCI University of California, Irvine

CalPolyPomona

SJSU SAN JOSÉ STATE UNIVERSITY

ABOUT THE TEA SUMMIT

Higher education institutions have been searching for ways to improve STEM education. A collaborative team from UC Irvine, San Jose State University, and Cal Poly Pomona established a cohort-based faculty development program in Summer 2021, the Teaching Experiment Academy (TEA). The goal is to assist faculty in redesigning the STEM curriculum with the components of mastery learning structure and specifications grading system to enhance the student learning experience and increase their inner growth mindset.

35 faculty who redesigned their STEM courses after participating in the academy will share their journey from curriculum redesign to implementing the new grading system in teaching. Come and explore how these faculty teach with mastery specifications grading and the impact of student learning outcomes generated by this new pedagogy.

Many thanks to the California Learning Lab and UC Irvine's Office of VP for Teaching and Learning for sponsoring the TEA program. We look forward to seeing you at the TEA Summit online!

MESSAGE FROM THE TEA PROJECT TEAM






STEM education has been transformed by a combination of pedagogical innovations and emerging technologies. Educators are eager to explore ways to engage students, foster learning experiences, and improve academic outcomes. The TEA Summit cultivates a robust faculty learning community, embracing teaching experience exchange and peer-led discussion on today's STEM education matters. By participating in the TEA summit, we hope faculty will be motivated to rethink teaching and ways to support the student learning experience, especially for the underrepresented and minoritized groups.

Sincerely,
Michael Dennin, *Vice Provost for Teaching and Learning, UC Irvine*
Megan Linos, *Director of LX Design & Online Education, UC Irvine*
Victoria Bhavsar, *Director of the Center for the Advancement of Faculty Excellence, Cal Poly Pomona*
Nikos Mourtos, Department Chair of Aerospace Engineering, *College of Engineering, SJSU*
Laura Sullivan-Green, *Associate Professor, Civil & Environ Engineering, SJSU*
Eileen Chen, *Instructional Designer, College of Engineering, SJSU*

KEYNOTE SPEAKER

04/28/22 @ 10 AM

RENÉE LINK, Ph.D.

Professor of Teaching, Department of Chemistry
University of California, Irvine

Renée Link is a Professor of Teaching in the Department of Chemistry at the University of California, Irvine (UCI) who designs, manages and teaches the organic chemistry lab courses taken by over 1,000 UCI students each year. Although her training was in organic chemistry methodology, she discovered that her true passion was in helping students learn organic chemistry. Her scholarly activity focuses on using active learning in large courses to create a more inclusive and equitable learning experience for students from all backgrounds. As a community college transfer student and first-generation college graduate, Professor Link serves as a mentor for UCI graduate and undergraduate students navigating the complex world of academia.

KEYNOTE: FINDING SUSTAINABLE APPROACHES TO TEACHING WITH INTENTION

We often replicate our teaching approaches, assessments, and course policies based on what we experienced as students or based on a syllabus handed down from colleagues. In the process of developing your course, have you ever paused to ask yourself why? Why am I using this assessment approach? Why did I choose this course policy? How are these choices impacting students, especially students who are not exactly like me? Truly addressing these questions can be challenging work. At the same time, structuring courses in ways that support students should not require sacrificing ourselves in the process. The choices we make must be sustainable for us and for any other members of our teaching teams. In this keynote we will explore how to approach our teaching with intentionality while making choices that are practical for us, our teaching team, and our students.

KEYNOTE SPEAKER

04/29/22 @ 10 AM

ROBERT TALBERT, Ph.D.

Professor, Department of Mathematics
Presidential Fellow for the Advancement of Learning
Grand Valley State University

Robert Talbert is a Professor of Mathematics and Presidential Fellow for the Advancement of Learning at Grand Valley State University. He holds an undergraduate degree in Mathematics from Tennessee Technological University and Master's and Ph.D. degrees in Mathematics from Vanderbilt University. He is the author of *Flipped Learning: A Guide for Higher Education Faculty* and co-author of the forthcoming book *Grading For Growth* with Prof. David Clark. Robert was a scholar-in-residence with Steelcase from 2017-2018, where he conducted research on active learning and active learning classrooms. In his current role in the GVSU president's office, Robert coordinates university-wide and cross-institutional initiatives to promote active learning and other research-based teaching practices, while continuing to teach 3-4 courses in the Mathematics Department each year. Robert writes about math, technology, productivity, and higher education at his website, rtalbert.org. He lives in Allendale, Michigan with his wife, three teenage children, and four cats.

KEYNOTE: THREE GRAND CHALLENGES FOR STEM EDUCATION

Higher education in general and undergraduate STEM education in particular were facing profound challenges to their relevance and long-term viability even before the Covid-19 pandemic. Accelerating change in the world at large, including but not limited to the pandemic, has made it clear that what has "worked" in undergraduate education in the past is not necessarily what will serve learners best in the future. We must respond to these challenges appropriately, with a problem-solving mindset. In this talk, I will outline three "grand challenges" for undergraduate STEM education posed as opportunities to change the way we teach our subjects for the better, and thereby better serve learners and situate both them and us for the years ahead.

28 APRIL — TODAY'S AGENDA

10:00AM - 10:45AM | KEYNOTE: FINDING SUSTAINABLE APPROACHES TO TEACHING WITH INTENTION

Presenter: Renée Link, Professor of Teaching, Department of Chemistry, UC Irvine

We will explore how to approach STEM teaching with intentionality while making practical choices for us, our teaching team, and our students.

11:00AM - 11:45AM | FACULTY INNOVATION SHOWCASE

Faculty from Chemistry, Computer science, Physics and Engineering will demonstrate how they implement mastery learning and specifications grading in teaching to improve the STEM learning experience.

Group 1	Group 2	Group 3
Alfredo Freites, *Chemistry*	***David Kirkby,*** *Physics*	***Gerasimos Kontos,*** *Engineering*
Irene Gassko*, Computer Science*	***Michael Ratz,*** *Physics*	***Kaikai Liu,*** *Engineering*
Rachel Martin, *Chemistry*	***Laura Tucker,*** *Physics*	***Yazdan Pedram Razi,*** *Engineering*

12:00PM - 12:45PM | ROUND TABLE

Faculty-led peer discussion on supporting students and enhancing STEM education. Share your vision and discuss the possibilities of future STEM learning environments with your peers.

1:00PM - 1:45PM | FACULTY INNOVATION SHOWCASE

Faculty from Biology, Mathematics, Meteorology, Physics, Statistics, and Engineering will demonstrate how they implement mastery learning and specifications grading in teaching to improve the STEM learning experience.

Group 4	Group 5	Group 6
Veronica Berrocal, *Statistics*	***Greg Placencia,*** *Engineering*	***Jodie Clark,*** *Meteorology*
Christopher Davis, *Mathematics*	***Mahima A. Suresh,*** *Engineering*	***Michelle Digman,*** *Engineering*
Berit Givens, *Mathematics*		***Franklin Dollar,*** *Physics*

1:45PM - 2:00PM | CLOSING REMARKS

Alison Baski, the Dean of Science and Interim Dean of Engineering at Cal Poly Pomona, will address today's STEM education at the end of the first day of the TEA summit.

29 APRIL

TODAY'S AGENDA

10:00AM - 10:45AM | KEYNOTE: 3 GRAND CHALLENGES FOR STEM EDUCATION

Presenter: Robert Talbert, Professor, Department of Mathematics, Grand Valley State Univ.

Professor Talbert will discuss the three "grand challenges" for undergraduate STEM education posed as opportunities to change the way subjects are taught to better serve learners and situate them for the years ahead.

11:00AM - 11:45AM | FACULTY INNOVATION SHOWCASE

Faculty from Biology, Chemistry, and Engineering will demonstrate how they implement mastery learning and specifications grading in teaching to improve the STEM learning experience.

Group 7	Group 8	Group 9
Aimee Edinger, *Biology*	***Brian Andrade,*** *Engineering*	***Patrick Hong,*** *Engineering*
Celia Faiola, *Biology*	***Tony Pan,*** *Engineering*	***David Wagner,*** *Engineering*
Igor Tyukhov, *Engineering*	***Shreeyukta Singh,*** *Chemistry*	***Jeyoung Woo,*** *Engineering*

12:00PM - 12:45PM | ROUND TABLE

Faculty-led peer discussion on supporting students and enhancing STEM education. Share your vision and discuss the possibilities of future STEM learning environments with your peers.

1:00PM - 1:45PM | FACULTY INNOVATION SHOWCASE

Faculty from Computer Science, Mathematics, and Engineering will demonstrate how they implement mastery learning and specifications grading in teaching to improve the STEM learning experience.

Group 10	Group 11	Group 12
Carlos Rojas, *Engineering*	***Burford Furman,*** *Engineering*	***Natascha Buswell,*** *Engineering*
Navrati Saxena, *Computer Science*	***Karina Novoa,*** *Mathematics*	***David Copp,*** *Engineering*
Mike Wu, *Computer Science*	***Mojtaba Sharifi,*** *Engineering*	***Jon-Erik Tateri,*** *Engineering*

1:45PM - 2:00PM | PEER REFLECTIVE DISCUSSION

Join a reflective discussion and share new learnings and teaching ideas to recap the two-day summit experience.

SHOWCASE PRESENTERS

ENGINEERING

Brian Andrade
Adjunct Professor
San Jose State University
4/29 @ 11:00AM

Natascha Buswell
Assistant Professor
UC Irvine
4/29 @ 1:00PM

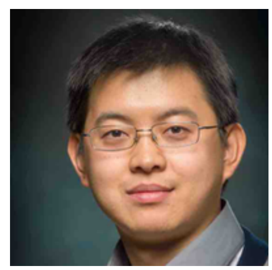
David Copp
Assistant Professor
UC Irvine
4/29 @ 1:00PM

Michelle Digman
Associate Professor
UC Irvine
4/28 @ 1:00PM

Burford Furman
Professor
San Jose State University
4/29 @ 1:00PM

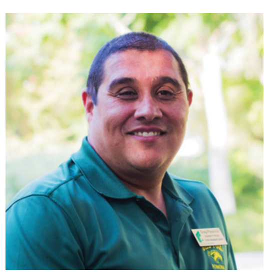
Patrick Hong
Lecturer
UC Irvine
4/29 @ 11:00AM

Gerasimos Kontos
Fulbright Visiting Professor
San Jose State University
4/28 @ 11:00AM



Kaikai Liu
Associate Professor
San Jose State University
4/28 @ 11:00AM

Tony Pan
Lecturer
San Jose State University
4/29 @ 11:00AM



Greg Placencia
Assistant Professor
Cal Poly Pomona
4/28 @ 1:00PM

Yazdan Pedram Razi
Adjunct Professor
San Jose State University
4/28 @ 11:00AM

Carlos Rojas
Assistant Professor
San Jose State University
4/29 @ 1:00PM

ENGINEERING

Mojtaba Sharifi
Assistant Professor
San Jose State University
4/29 @ 1:00PM

Mahima Agumbe Suresh
Assistant Professor
San Jose State University
4/28 @ 1:00PM

Jon-Erik Tateri
Lecturer
UC Irvine
4/29 @ 1:00PM

Igor Tyukhov
Adjunct Professor
San Jose State University
4/29 @ 11:00AM

David Wagner
Assistant Professor
San Jose State University
4/29 @ 11:00AM

Jeyoung Woo
Assistant Professor
Cal Poly Pomona
4/29 @ 11:00AM

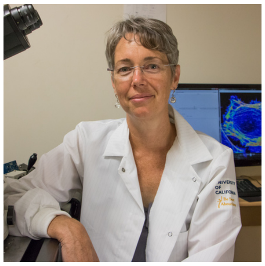
COMPUTER SCIENCE

Irene Gassko
Lecturer
UC Irvine
4/28 @ 11:00AM

Navrati Saxena
Assistant Professor
San Jose State University
4/29 @ 1:00PM

Mike (Ching-Seh) Wu
Assistant Professor
San Jose State University
4/29 @ 1:00PM

BIOLOGY



Aimee Edinger
Professor
UC Irvine
4/29 @ 11:00AM

Celia Faiola
Assistant Professor
UC Irvine
4/29 @ 11:00AM

CHEMISTRY

Alfredo Freites
Lecturer
UC Irvine
4/28 @ 11:00AM

Jessica Kelz
Grad Student Researcher
UC Irvine
4/28 @ 11:00AM

Rachel Martin
Professor
UC Irvine
4/28 @ 11:00AM

Shreeyukta Singh
Lecturer
San Jose State University
4/29 @ 11:00AM

MATHEMATICS & STATISTICS

Veronica Berrocal
Associate Professor
UC Irvine
4/28 @ 1:00PM

Christopher Davis
Associate Professor
UC Irvine
4/28 @ 1:00PM

Berit Givens
Department Chair
Cal Poly Pomona
4/28 @ 1:00PM

Karina Novoa
Lecturer
Cal Poly Pomona
4/29 @ 1:00PM

PHYSICS

Franklin Dollar
Associate Professor
UC Irvine
4/28 @ 1:00PM

David Kirkby
Professor
UC Irvine
4/28 @ 11:00AM

Michael Ratz
Professor
UC Irvine
4/28 @ 11:00AM

Laura Tucker
Assistant Professor
UC Irvine
4/28 @ 11:00AM

METEOROLOGY & CLIMATE SCIENCE

Jodie Clark
Lecturer
San Jose State University
4/28 @ 1:00PM

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Special thanks to the California Learning Lab project and UC Irvine's Office of Vice Provost for Teaching and Learning for sponsoring this program.

Leveraging Technology-based Instructional Material with Group Problem-Solving to Flip the Organic Chemistry Curriculum

Sabbatical Project Proposal
Academic Year 2021-2022

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Abstract

Within the past decade there is accumulating evidence for the efficacy of the flipped learning model in helping students succeed in science, technology, engineering and math (STEM) courses. The key feature of flipped learning is that the bulk of the traditional lecture is delivered to the students outside of class, while class time is reserved for more active learning activities. The goal of this sabbatical project is to use technology-based instructional material to implement the flipped learning model in Chemistry 80, the first semester of the year-long sequence of organic chemistry. To accomplish this goal, the project includes an independent study of the flipped learning pedagogy and development of the following instructional materials: 1) video lectures using the Lightboard technology to be hosted on YouTube, 2) PlayPosit modules to monitor student viewing, and 3) worksheets and quizzes for in-class engagement. The flipped learning model applied to Chemistry 80 will help Mt. San Antonio College students succeed in the last sequence of second-year chemistry, which is increasingly required in order for students to be on track to graduate upon transfer to a four-year institution.

Introduction

Flipped learning has emerged in the last two decades as an attractive alternative teaching method to the traditional college lecture. First formally applied in an introductory microeconomics course by Professor Maureen Lage and her colleagues at Miami University in the early 2000s, flipped learning was initially coined as "inverting the classroom" where, the traditional lectures were delivered via multi-media *before* class and "homework" was re-designed as group problem-solving activities for active learning *during* the formal class time (1). The idea of having students be exposed to subject material before coming to class predates the Miami University study, but what was novel is the incorporation of multi-media rather than previous iterations of this pedagogy where students were assigned pre-lecture textbook readings – and this important distinction has made Flipped Learning increasingly more attractive and effective. Over the years the model has evolved into a pedagogy that has been applied to every academic discipline, and more recently evidence of its effectiveness has emerged in the STEM disciplines.

The material load in STEM courses often are heavy with theories and their application in problem-solving. In the traditional class, generally called "lecture" style, the instructor devotes a large percentage of the class time introducing theories, explaining concepts and showing examples of application. In this mode, due to limited class time, students tend to be passive learners and engage with the material when doing homework outside of class. This mode of learning may work for some students, but a growing body of evidence shows that a more active learning approach improves learning and performance of students in undergraduate STEM courses and at the same time is more inclusive of students with diverse learning styles and preparedness (2). Active learning is especially effective in reducing the achievement gaps for students from underrepresented groups (3); an important finding as underrepresented minority students is the majority of the student population served at Mt. San Antonio College (Mt. SAC). As an active learning pedagogical approach, flipped learning in particular, has also been shown to be an effective tool across disciplines and education levels (4), and in Chemistry in particular (5, 6, 7).

Flipped learning, in essence, did not emerge purely from education theories and cognitive science but rather organically by the recognition from veteran educators of the learning and achievement gap of students with diverse learning style and preparation. It is not a silver-bullet approach but has been refined over the years through best-practices. Nonetheless, flipped learning is supported by cognitive load theory, which is based on the notion that learning is a process that occupies the working memory, which is finite. When novice students are required to learn new material, and especially material that is intrinsically complicated, and at the same time make connections to previously learned material stored in the long-term memory, this presents an overload on the working memory and retaining of new information, resulting in lower learning outcomes (8). The flipped learning model aims to alleviate this cognitive load by allowing students to learn at their own pace and thus more inclusive in accommodating individual learners (9).

Rationale, Project Goals and Outcomes

My proposal is to apply the flipped learning model to Organic Chemistry 1 (Chemistry 80), which is the first course in a 2-semester sequence in the second-year college level chemistry. The structure of my flipped learning methodology will include two segments for which I will briefly describe below.

Before Class. Before every class, students are assigned to watch online video lectures hosted on playposit.com. These lectures cover topics to the same depth that I would normally cover in a traditional classroom. However, in this method students have the advantage of both time and space – students can watch the videos wherever and whenever they want, at the speed they want, how many times they want so they can absorb the material at their own pace. While watching the video there will be pauses where students answer checkpoint questions. To lower the anxiety and promote learning, these questions will not be graded but must be answered in order for students to finish the video and earn the pre-lecture points. Students are encouraged to take notes as if they were sitting in class. Students are also assigned to read the textbook before and/or after they watch the videos.

During Class. When coming to class, students will jump right into the material, working in groups of three to four students on what might be traditionally considered homework problems. At this time, the instructor is available for questions and if a topic receives multiple inquiries, a class discussion or impromptu lecture may be launched. These activities provide copious amounts of student-student and student-instructor interactions that not only engage the students in valuable class time but provide the instructor with multiple points of intervention with immediate instructor feedback.

Need of the Project

Organic chemistry is notorious for being one of the most difficult courses in the undergraduate curriculum (10) and one that all students majoring in chemistry, biology and pre-medical sciences (e.g. optometry, dentistry, pharmacy and medicine) need to pass. Students approach the class with much trepidation and often find the pace of the class too fast (11). This may be attributed to the abstract nature of organic chemistry (for example students need to grasp the skill of relating 3-dimensional structures to their 2-dimensional representations in order to determine functionality and reactivity) and the large quantity and complexity of chemical reactions that is covered (12). Thus, success in organic chemistry requires not only constant practice from the students, but the close guidance of the instructor to help students apply the concepts, gain mastery and build confidence (13). With much to cover in a semester, the instructor in a traditional classroom spends a vast majority of the time in class introducing the material to students, leaving students to struggle with the material outside of class, often alone. One way to slow down the pace of the class is to leverage technology to push the lecture component outside of class. With the lecture delivered via videos at home, students can pause or rewind, literally slowing down the pace of the class, minimizing the cognitive load and accommodating different learning styles. The class time now is more student-centered as the instructor is removed from the podium and directly interacting with students and providing timely feedback.

This mode of learning is especially beneficial for STEM students at Mt. SAC. With the increased demand in science courses in general and organic chemistry in particular within the last several years, this pedagogical tool is increasingly more vital. Due to student demand, Mt. SAC's Chemistry department has consistently increased the number of Chemistry 80 sections offered per academic year within the last decade (Figure 1). With 24 students per class and 10 sections a year, on average 240 Mt. SAC students enroll in Chemistry 80 on an annual basis, ranging from students majoring in chemistry and biology to nursing. At the same time, due to increasing number of sections, the percentage of the sections taught by full-time chemistry faculty has decreased. In the academic year 2010-2011, with 5 sections 80% were taught by full-time instructors, compared to 2019-2020 with 9 sections it was only 22%.

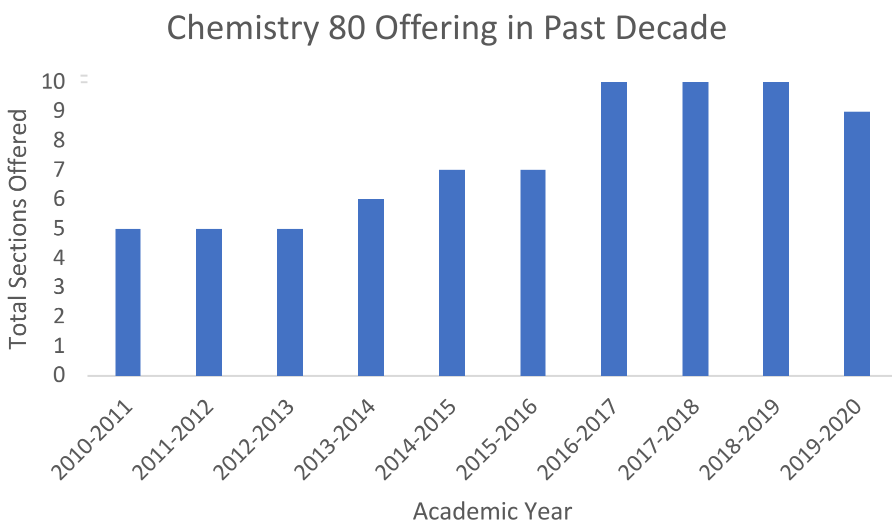

Figure 1 Chemistry 80 offering doubled within the last 10 years. Mt. SAC's chemistry department have seen a gradual demand for Chemistry 80. The graph shows the total number of sections for Chemistry 80 offered per academic year (fall and spring semester combined).

With the growing enrollment of Chemistry 80, it is projected that implementation of the flipped learning methodology will help more students succeed. Currently, the success rate (percentage of students passing the class with marks of A, B, C or P) of Chemistry 80 have held steady in the mid-seventies (Figure 2). With one in four enrolled students failing Chemistry 80 a year, it is important for the Chemistry Department and school to find creative ways to close this achievement gap. In particular, the implementation of the lecture videos will have an out-sized impact on students with adjunct instructors, who are increasingly the majority of Chemistry 80 instructors. There are for two main possible reasons: 1) these instructors have fewer office hours and 2) they often have less experience teaching the course. First, with less office hours, students in a traditional classroom who are already struggling on their own outside of class encounter an added frustration: fewer opportunities to seek help from the instructor. The lecture videos will help these instructors adopt a flipped learning approach and provide much-needed instructor support during valuable class time. Even if a flipped learning approach is not adopted, the video lectures will provide a resource for students as the material is consistent with the learning objectives adopted by the department, saving students time and effort in seeking YouTube material to supplement instruction. Second, as adjunct instructors prefer a less intense course for their teaching load, they often cycle in-and-out of organic chemistry more frequently, resulting in a higher rate of first-time organic instructors. The lecture videos from this project will serve as support and calibration for these less experienced part-time instructors.

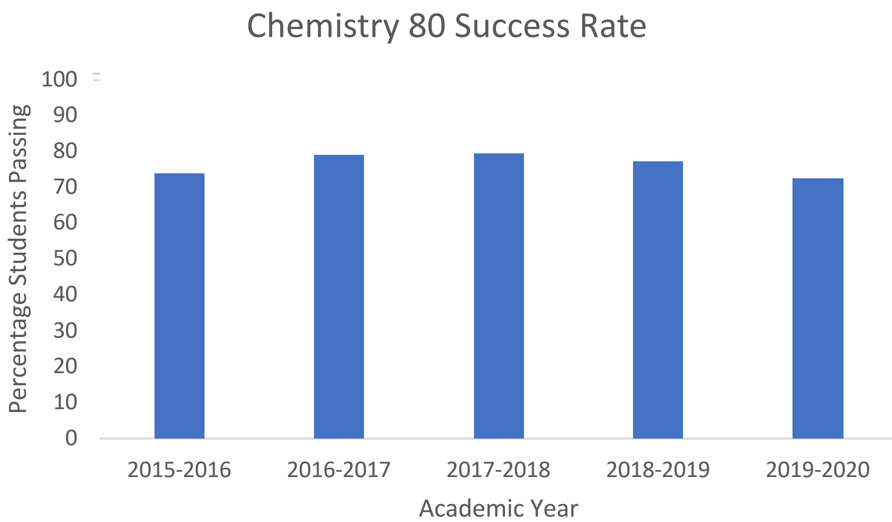

Figure 2 Success rate of Chemistry 80 for the past 5 years have held steady. The success rate is fined by the total number of students receiving passing grades (grades A, B, C or P) divided by the total enrolled students (including students receiving D, F and W marks). Over the past 5 years the success rate averages to 77.5% (note this overage does not include academic year 2019-2020; due to COVID-19 data for Spring 2020 is incomplete).

Independent Study and Project Description

To support my proposal to leverage technology-based instructional material with group problem-solving to apply flipped learning pedagogy to first-semester Organic Chemistry, I will devote my sabbatical independent study and project to the following activities:

1. Independent study of the leading literature on the flipped learning methodology
2. Production of lecture videos for Chemistry 80
3. Creation of auxiliary educational material for Chemistry 80: PlayPosit assignments, in-class worksheets and daily quizzes
4. Conference participation in flipped learning community

Activity 1 – Independent Study. By attending conferences and discussing best-practices with colleagues at Mt. SAC and across different campuses in the country through professional conferences, I have gained a working knowledge on flipped learning. Starting my sabbatical, I would like to dive deeper into the current literature discussing the efficacy and methodology of flipped learning, including best practices for its implementation in organic chemistry. In addition to updating my knowledge by surveying peer-reviewed research manuscripts from such established journals like American Chemical Society's (ACS) *Journal of Chemical Education*, I will also be studying the foundational flipped learning textbook: *Flip Your Classroom – Reach Every Student in Every Class Every Day* by Jonathan Bergmann and Aaron Sams (14). Using this book as a guide, I will reflect on my own experiences with the flipped learning approach, its triumphs and pitfalls in order to make concrete adjustments in my application of the theory in my classroom.

Activity 2 – Video Lecture Production. The bulk of my efforts will be in this activity. It is important to be able to create video lessons for students to watch in a flipped learning model. If students are merely assigned readings and video lessons that are not created specifically for the class they will not fully benefit from the flipped learning approach. Many of them will feel that they are basically teaching themselves and will not buy into the flipped learning framework. Student buy-in in the pedagogy is crucial for its success. This is why I have decided to incorporate video lessons as my pre-class component.

The Natural Science division purchased the Lightboard technology, now physically housed in Professional & Organizational Development (POD), that allows the instructor to present a lesson by writing on the ultra-clear LED board while at the same time maintaining eye-contact and gesture visibility. These visual enhancements will help the instructor keep the attention of students as they watch the video lesson, allowing the instructor to engage with the students through complex material. I will use my independent study to best leverage this technology to record my lecture videos. I will be working with POD to obtain training in the use of the Lightboard and will serve as one of the faculty experts to train others in its use.

As with past experience (see *Merit and Value to Chemistry Program*) this video-recording step is the most time-consuming. I will organize my project to record fourteen chapters from *Organic Chemistry* by David Klein, the official adopted textbook of Chemistry 80 (see *Independent Study and Project Timeline* page 8-9 of this proposal) and each chapter will have two to four lessons. Although the video for each lesson may only be 40-60 minutes in length, the time to produce each is often 10-fold more. This is because the video production not only covers the recording itself (which may take several tries and many out-takes) but the preparation of notes before the recording and the meticulous task of post-production editing. I will continue to use iMovie for post-production editing and host the lecture videos on my YouTube channel:

https://youtube.com/channel/UCZ3vdNBhVFYtgt6mWugye7g

The lecture videos are assigned before class but with my experience I have seen that students on average watch the videos five times before the semester is over. Some students find it helpful to watch the videos multiple times when first learning the material. While other students find it a useful review tool before an exam. In addition to the feature of multiple views, the fact that it can be watched at a slower pace or paused whenever needed provides great accommodation to students with a wide range of learning styles, ultimately fostering a more inclusive and equitable learning environment.

Activity 3A – Creation of PlayPosit Assignments. PlayPosit is an online educational platform that allows instructors to host video lessons with different active learning features. Not only does this platform allow for the instructor to know which students are watching the video lessons but also allow the instructor to have a glimpse into the understanding level of the students. Questions can be inserted in any point of the video to check-in with the students. They range from a simple pause-and-reflect with an essay-type response or a multiple-choice quiz-like question that provides the student immediate feedback as the answer is revealed upon submission (Figure 3). These activities all promote a more active viewing of the lecture – even more so than a canonical in-person traditional lecture. The results of these quiz questions and their aggregate data can also be used by the instructor in class to provide "just-in-time" instruction that addresses common mistakes or gaps of knowledge of the class as a whole. As part of the design process of the PlayPosit assignments, I will watch the final-cut of each video lesson to craft interactions that reviews and connects concepts, promotes critical thinking and/or check new concept understanding. To keep the students engaged I will create interactions for every three to four minutes of video.

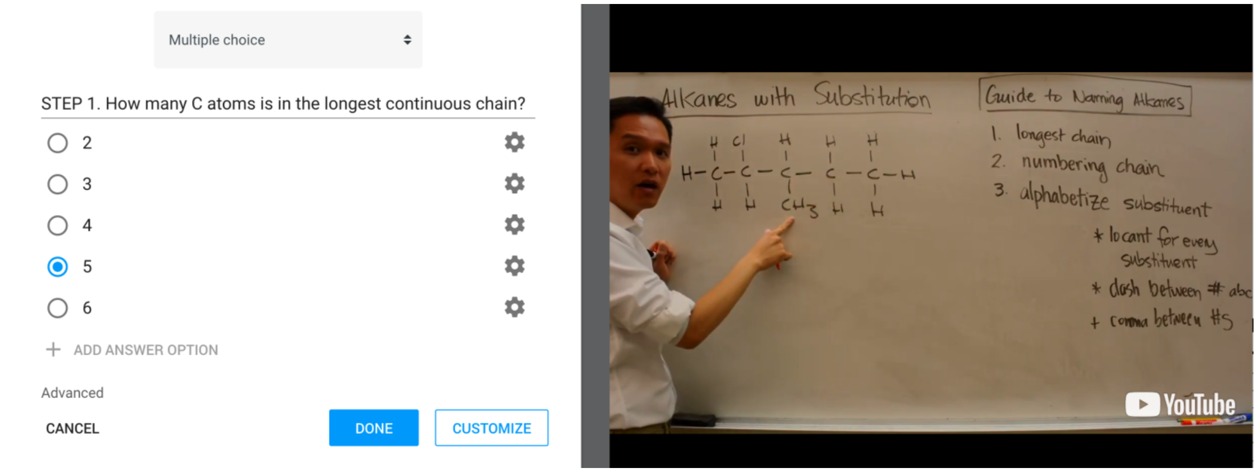

Figure 3 Example of PlayPosit Interaction. Shown here is a screenshot of the PlayPosit interaction applied in a pilot flipped learning model for Chemistry 10 (further discussed in *Merit and Value to Chemistry Program*). Once videos are hosted on YouTube they can be embedded into PlayPosit. One active learning feature in PlayPosit is the ability to insert "check-point" questions to engage the students. Often this is a multiple-choice type question so that students receive immediate feedback on their understanding.

PlayPosit Alternative. Currently PlayPosit is available under an institutional license funded by the District, which is set to expire June 30, 2021. In the event that this contract is not renewed, I will explore viable alternatives that still employ the video lectures and thus facilitate the flipped learning methodology. First, there are other technology platforms that can be used. For example, EDPuzzle can also allow the instructor to assign video lectures and track student progress. However, the free version of this platform limits the instructor to use only 20 lessons at a time. A second alternative is to skip these paid systems all together. I will explore Vizia, which is a completely free platform, that allows the instructor to insert questions to any YouTube video. The student answers are then saved to a Google Sheet, which is also a free service. A third alternative that will not involve any platforms, and thus avoiding cost and student authentication issues, is to assign quizzes via Canvas. These questions can be the same questions as the ones posted on PlayPosit, except they would have a preface, for example: "watch the video up to 5:35, then answer this question." This last alternative is not as sophisticated but will serve the purpose of creating active learning experiences with the lecture videos.

Activity 3B – Creation of Worksheets and Quizzes. The last component to the flipped learning model is the valuable class time. This is the time for students to struggle more with the material, but this time they have the added benefit of discussions with their peers and the guidance of the instructor. During the beginning of the class students are collaborating in groups of three to four to work on the practice worksheets. These problems are similar to what is traditionally "homework" problems and will be derived from the Course Measurable Objective to help students direct their attention to the most important skills and concepts covered. Near the end of the session, selected students will put answers on the board to explain to the entire class. Both of these aspects provide for a social learning experience for students that has been shown to promote greater knowledge acquisition and retention (15). By the end of the week, a quiz is administered to assess the students' mastery of the material. This frequent testing technique has been shown to help students learn and reduce the achievement gaps as it requires students to practice retrieving and reconstructing knowledge as part of what researchers call deep learning (16, 17). I will devote time to create these worksheets and quizzes. Along with the videos, these auxiliary educational materials will be shared with colleagues teaching Chemistry 80, whether they decide to adopt the flipped learning pedagogy in full or in part.

Activity 4 – Conference Attendance and Participation. The last component of my independent study and project will be attendance and participation of premiere conferences in chemical education. My aim is to attend two national meetings. The first is to attend the 27th Biennial 2-Year College Chemistry Consortium (2YC3) conference hosted by ACS which focuses entirely on chemistry education at 2-year institutions and the success of community college students in chemistry. Due to COVID-19 the dates of this conference are not yet published at the time this proposal is submitted. The second conference is the Gordon Research Conference on Chemistry Education Research and Practice, where leaders at the frontiers of disciplined-based education research will share their latest findings in chemical education. I have attended this meeting in 2017 where I was exposed to flipped learning and this time I would like to revisit and share my knowledge with its implementation at the community college level.

Independent Study and Project Timeline

Fall Semester 2021

Week of	Description of Activity	Length of Activity (Hour)
August 30	Independent study: Bergmann J. and Sams A., (2012), *Flip Your Classroom: Reach Every Student in Every Class Every Day*	30
September 6	Updating literature survey concerning flipped learning Exploring Lightboard and associated software Researching and experimenting with editing software	10 10 10
September 13	**Ch. 1 Review of General Chemistry** Preparing notes, writing scripts and recording lecture	 30
September 20	Post-production editing Creating PlayPosits, Worksheets and Quizzes	20 10
September 27	**Ch. 2 Molecular Representations** Preparing notes, writing scripts and recording lecture	 30
October 4	Post-production editing Creating PlayPosits, Worksheets and Quizzes	20 10
October 11	**Ch. 3 Acids and Bases** Preparing notes, writing scripts and recording lecture	 30
October 18	Post-production editing Creating PlayPosits, Worksheets and Quizzes	20 10
October 25	**Ch. 4 Alkanes and Cycloalkanes** Preparing notes, writing scripts and recording lecture	 30
October 25	Post-production editing Creating PlayPosits, Worksheets and Quizzes	20 10
November 1	**Ch. 5 Stereoisomerism** Preparing notes, writing scripts and recording lecture	 30
November 8	Post-production editing Creating PlayPosits, Worksheets and Quizzes	20 10
November 15	**Ch. 6 Chemical Reactivity and Mechanisms** Preparing notes, writing scripts and recording lecture	 30
November 22	Post-production editing Creating PlayPosits, Worksheets and Quizzes	20 10
November 29	**Ch. 7 Alkyl Halides (Part 1)** Preparing notes, writing scripts and recording lecture	 30
December 7	Post-production editing Creating PlayPosits, Worksheets and Quizzes	20 10

Spring Semester 2022

Week of	Description of Activity	Length of Activity (Hour)
February 28	**Ch. 7 Alkyl Halides (Part 2)** Preparing notes, writing scripts and recording lecture	 30
March 7	Post-production editing Creating PlayPosits, Worksheets and Quizzes	20 10
March 14	**Ch. 8 Addition Reactions of Alkenes** Preparing notes, writing scripts and recording lecture	 30
March 21	Post-production editing Creating PlayPosits, Worksheets and Quizzes	20 10
March 28	**Ch. 9 Alkynes** Preparing notes, writing scripts and recording lecture	 30
April 4	Post-production editing Creating PlayPosits, Worksheets and Quizzes	20 10
April 11	**Ch. 10 Radical Reactions** Preparing notes, writing scripts and recording lecture Post-production editing Creating PlayPosits, Worksheets and Quizzes	 15 10 5
April 18	**Ch. 11 Synthesis** Preparing notes, writing scripts and recording lecture Post-production editing Creating PlayPosits, Worksheets and Quizzes	 15 10 5
April 25	**Ch. 12 Alcohols and Phenols** Preparing notes, writing scripts and recording lecture	 30
May 2	Post-production editing Creating PlayPosits, Worksheets and Quizzes	20 10
May 9	**Ch. 14 Infrared Spectroscopy** Preparing notes, writing scripts and recording lecture Post-production editing Creating PlayPosits, Worksheets and Quizzes	 15 10 5
May 16	**Ch. 15 Nuclear Magnetic Resonance Spectroscopy** Preparing notes, writing scripts and recording lecture	30
May 23	Post-production editing Creating PlayPosits, Worksheets and Quizzes	20 10
May 30	Writing Sabbatical Report	30
June 6	27th Biennial Conference on Chemical Education*	30
June 13	Writing Sabbatical Report	30

*Conference date is scheduled tentatively in June 2022.

Merit and Value to Chemistry Program

For the past several semesters I have implemented a flipped learning model in my Chemistry 10, Chemistry for Allied Health Majors course. I present here the preliminary data and conclusions for the success of the implementation of the flipped learning model for Chemistry 10 and equally important, students' response to this new way of learning.

Conclusion 1 – Flipped Learning Support Student Success. One way to measure success with the flipped learning model is to compare the completion rate with that of the traditional lecture classroom. To achieve this, I looked at the final course grades between two back-to-back semesters: Fall 2017 with a traditional lecture and Spring 2018 with flipped learning. The data shows that the passing rate (grades A, B and C) for traditional lecture of 84.3% was improved to 92.9% in the flipped learning model. Moreover, among the students that passed the class a higher percentage received an A-letter grade (31.4% to 50.0%), and a smaller percentage received a C-letter grade (19.6% to 10.7%) upon the switch to flipped learning (Figure 4). The comparison of back-to-back semesters with two different pedagogical approach, although limited in quantity of data points, shows a promising trend in the efficacy of the flipped learning approach.

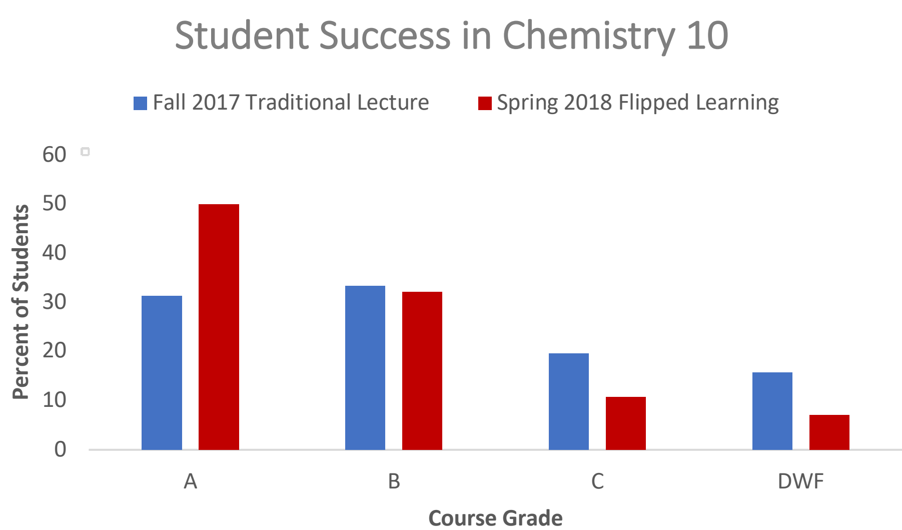

Figure 4 Student Success Rate in Chemistry 10 Before and After Implementation of Flipped Learning Pedagogy. Student course grades are compared between Fall 2017 semester of Chemistry 10 where traditional lecture format was used (blue bars, N=51) to Spring 2018 semester where a flipped learning method was implemented (red bars, N=28). Course grades that show successful completion of the course are A, B and C. Whereas a D grade, a withdrawal (W) and an F grade measures the rate of unsuccessful attempt, collectively called "DWF" in the plot. The trend shows more student overall are successful in the class in the flipped learning format and that among students who passed the class on average a higher grade was earned.

Conclusion 2 – Flipped Learning Support Student Learning. Students show a sizeable increase in their learning in the flipped learning framework. More data needs to be analyzed to more strongly support this claim (comparing Student Learning Outcomes or Midterm Exams scores, for example) but preliminary data from the Final Lecture Exam shows a marked increase in student performance (Figure 5). In the traditional lecture format students earned an average of 66.7% on a 75 multiple-choice test covering topics from the entire semester. In the flipped learning format students on average saw a 4.1% increase to 70.8%.

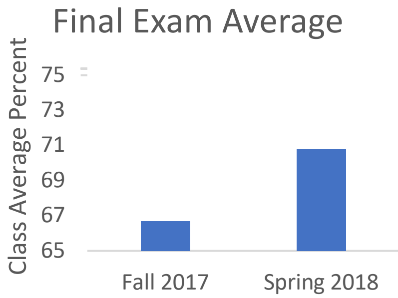

Figure 5 Student Performance on the Chemistry 10 Final Exam Before and After Implementation of Flipped Learning Pedagogy. Student course grades are compared between Fall 2017 semester of Chemistry 10 where traditional lecture format was used to Spring 2018 semester where a flipped learning method was implemented. A 4.1% increase on average was gained upon switching to flipped learning.

Conclusion 3 – Students Prefer Flipped Learning Where Video Lectures Are Used. The most important lesson I have learned in discussing the flipped classroom model with my colleagues and current students is that the success of the flipped learning model depends on the willingness of the students to this often-unfamiliar mode of learning. Knowing the crucial factor of student buy-in, I adopted a flipped classroom learning modality based on creating my own video lectures assigned before class on PlayPosit and saving class time for practice worksheets and quizzes. In my first semester of implementing the flipped learning I surveyed the students (N=25) to gauge their perspective on their learning and success in the course. Overwhelmingly, students preferred the flipped learning model over the traditional lecture (Figure 6, blue graphs). Students also felt that their level of engagement in the flipped learning model was increased (Figure 6, gray graphs). Interestingly, despite not all students personally preferring flipped learning, they unanimously recommended its continuous implementation for future semesters (Figure 6, red graphs).

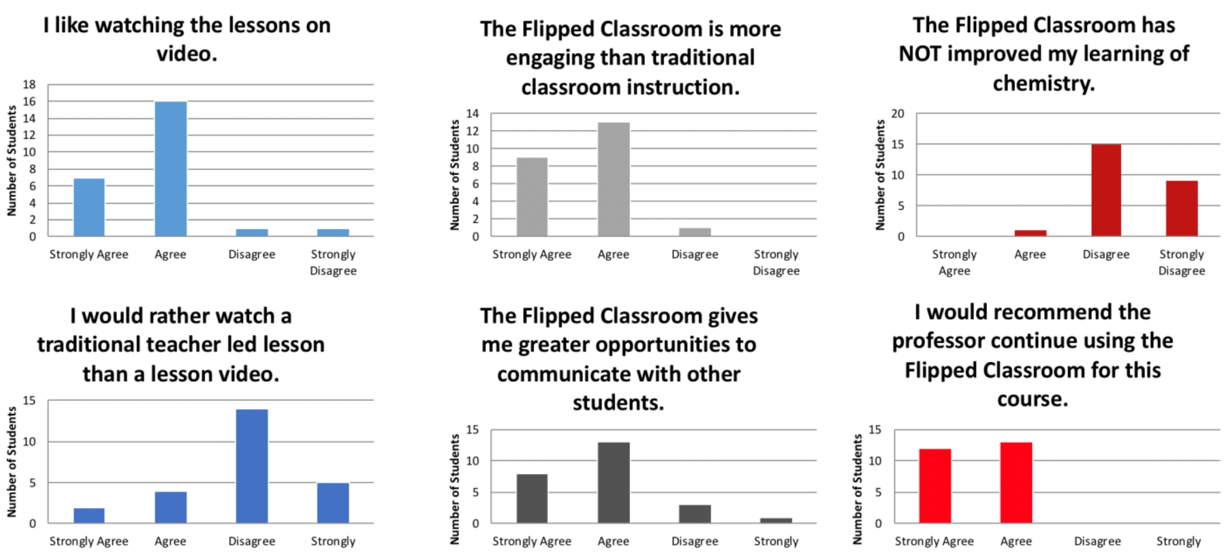

Figure 6 Student Perspective on Flipped Learning in Chemistry 10. A Likert Scale survey was conducted anonymously at the end of the Spring 2018 semester for 25 Chemistry 10 students. Blue graphs (left column) show student sentiment on traditional lecture style versus watching videos in the flipped learning model. Gray graphs (middle column) show student view on their own level of engagement in a flipped learning classroom. Red graphs (right column) show student overall impression of the efficacy of the flipped learning model.

The videos created for Chemistry 10 was not only useful for students in my class. I was also able to share with other instructors, both full-time and adjunct professors. I have included letters of support from two colleagues (Professors Masoud Roueintan and Maritess Oda) who have found much benefit in the video lectures. This resource was even more appreciated during the COVID-19 pandemic when teaching was transitioned online. These instructors were able to quickly adapt to a flipped learning mode where the synchronous class time was reserved for practice problems by using my lecture videos as pre-class assignments.

I believe all of the potential benefits that has emerged from my Chemistry 10 experience will translate into Chemistry 80 as outlined in this proposal. The flipped learning model with the lecture videos will help Chemistry 80 students in learning and succeeding in the course that not only has the perception of being difficult but also suffers from a low passing rate. Furthermore, as with the Chemistry 10 lecture videos, I believe that my Chemistry 80 lecture videos will also be helpful to adjunct instructors and new full-time instructors in the course and benefit the 240 Mt. SAC students that take the course every year (as discussed in my *Rationale*). These students are not only students majoring in chemistry, but also biology and increasingly nursing students; for example, the bachelor of science degree in nursing at University of California Irvine and Los Angeles requires completion of the first semester of organic chemistry, the equivalent of Chemistry 80 at Mt. SAC.

Merit and Value to Faculty

In my class I always teach my students the importance of being a life-long learner – to stay curious and open to new knowledge. I take this philosophy to heart as an educator. Every semester, even when I teach the same course, it is never the same experience, never the same syllabi. This ranges from the specifics like incorporating new examples in my lectures, to the broader pedagogical approach of adopting new active learning techniques. As an educator and a scientist, I am driven by my desire to perfect my art of teaching by experimenting with innovative pedagogy and evaluating their effectiveness. My reward is not only knowing that I can contribute to the field of education research but also know that I am helping my students succeed. In my view, even though I am teaching rigorous STEM courses often notoriously viewed as gate-keeper courses to "weed out the weak," my job is to find ways through my pedagogy to support the under-prepared, under-served and under-represented students so they may have an equitable chance of success.

Because of this quest for innovative teaching and learning I have attended many professional meetings and conferences, from in-house workshops offered by Mt. SAC's Professional & Organizational Development to national meetings like the ACS sponsored 2-Year Community College Consortium Conference or Gordon Research Conference (GRC) on Chemistry Education Research and Practice. In fact, my first introduction to flipped learning pedagogy was at the Spring 2017 Flex Day seminar hosted by Phillip Wolf of the Physics Department, "How to Flip Your Class and Why You'd Want To," where he presented his sabbatical project flipping General Physics (Physics 2AG). Later that year, at the GRC conference I was exposed to exciting data on the efficacy of the flipped learning model in chemistry education. At this premiere discipline-based education research conference, I had the opportunity to talk to professors across North America about their research on flipped learning and about their experiences and best practices.

When I came back from the GRC conference I devoted my entire summer and winter break that year (and all my Fridays during the Fall semester) to implement the flipped model for my Chemistry 10 course in the Spring 2018 semester. From this experience I have realized the enormous amount of effort it takes to flip a course. It is for this reason I will need a sabbatical project in order to attempt flipping Chemistry 80, a much more advanced course. The sabbatical project will also allow me to do more research into the science of flipped learning. To this end I will be engaged in self-study by starting my sabbatical by reading the foundational work on this topic by Bergmann and Sams called *Flip Your Classroom: Reach Every Student in Every Class Every Day*. I will further survey the literature of chemical education from such publications as Journal of Chemical Education. At the end of my project I plan to attend the 27th Biennial Conference on Chemical Education hosted by 2YC3. At this conference I hope to exchange knowledge with my colleagues across the country in our efforts and discoveries in science education. Ultimately, these activities will enrich my experience in academia.

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