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March 24, 2022

Dr. Jaclyn Stewart
Associate Dean Academic of Science
University of British Columbia
Vancouver, BC V6T 1Z4

Subject: Letter of Transmittal

Dear Dr. Stewart:

Here is my report, the Assessment of Organic Chemistry Education at UBC. While drafting this report, I have gained a new perspective on education and respect for instructors. Additionally, the sentiment that students shared was interesting to learn about and provided insight on the quality of education they believed they had received. The information in this report will aid the Chemistry Department make decisions on how to adjust their courses to ensure that the quality of education being provided is high in quality. I appreciate your guidance throughout this process, and I would like to thank you for your assistance through the writing process.

Students pursuing a career in life sciences will be introduced to organic chemistry early on in their academic career. Many students expressed concern over the difficulty of the material and felt that the methods used to communicate the material could be improved. The goal of this report is to identify areas of concern regarding the quality of organic chemistry education. Students have indicated two areas to improve the quality of organic chemistry education, including evaluation methods and the introduction of tutorial-based classes to promote active learning.

I enjoyed my work during this process and have learned a lot on how to conduct survey research and write a formal report. If you have any questions regarding the report, please do not hesitate to contact me at jkuan99@student.ubc.ca.

Regards,

Jackson Kuan

Assessment of the Quality of Organic Chemistry Education at UBC

For

Dr. Jaclyn Stewart

Associate Dean Academic of Science

University of British Columbia

Vancouver, BC

By

Jackson Kuan

English 301 Student

March 24, 2022

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ABSTRACT

A high quality of organic chemistry education is important for individuals pursuing a career in the life sciences. A strong foundation and understanding of organic chemistry concepts are pertinent to finding success in careers within academia or the biotechnology industry.

Organic chemistry is inherently difficult and is comparable to learning a new language. As a result, the traditional instructional methods used to convey the material may not be effective and a new form of active learning should be introduced. Furthermore, adequate amounts of feedback are essential for student learning, as it allows them to pinpoint areas of confusion, and learn from their own mistakes.

The quality of organic chemistry education at UBC was analyzed based on the firsthand experiences of current and past undergraduate students. Additionally, the learning process from a professor's standpoint was investigated through an interview with Dr. Jaclyn Stewart.

For students to receive a high quality of education in organic chemistry, the institution and teaching staff should take these suggestions into consideration:

- Promoting the use of active learning in a classroom setting may aid in communicating the material
- Providing students problem sets or in class worksheets will aid in finding gaps in their knowledge
- Encouraging student participation in class and online discussion boards will cultivate a sense of belonging

I - INTRODUCTION

A. Background in Organic Chemistry

Organic chemistry is a staple in the academic careers of life science students. This subject provides the foundation in which life science concepts are built upon; therefore, a high quality of organic chemistry education is essential. While this subject is mandatory for most individuals, students have expressed concern over the subject matter. Organic chemistry is known as one of the more challenging topics for undergraduate students due to its nature of topic progression. Furthermore, organic chemistry is not intuitive and relies on pictorial representations to explain convoluted concepts (Graulich 19). The use of pictorial representations makes organic chemistry a language of its own that one must learn prior to understanding the concepts within it.

B. Purpose of the Report and Analysis of Concerns

The purpose of this report is to identify any areas of concerns regarding the quality of organic chemistry education at the University of British Columbia (UBC) from a student's perspective. One area of concern is the teaching method professors are using while teaching organic chemistry. Educational psychology studies have shown that active learning is more effective at communicating the material, consequently improving memory retention in students (Prince 224).

What is Active Learning?

The notion of active learning has a wide variety of definitions. The main concept of active learning is centered around the student working through instructor-led activities, which differs from traditional lecture-based teaching methods (Hartikainen et al. 216). Some examples of

active learning include the use of poll questions or in class worksheets. In theory, it is defined as an instructional practice instead of a learning concept.

Organic chemistry is a visual science, therefore spatial comprehension is needed to visualize two dimensional representations as three dimensional molecular structures (Graulich 19). As a visual science, the use of images and visual aids are more effective at communicating the material compared to the traditional methods of lecturing and text. As science continues to evolve, the methods used to teach science should evolve alongside it. Another area of concern are the evaluation methods that are implemented into courses. Classes that utilize closed-book examinations may not be effective in evaluating a student's knowledge on organic chemistry, and do not provide the student sufficient feedback throughout the semester for them to identify gaps in their knowledge.

C. Potential Solutions to Areas of Concern

Due to academic freedom, professors have the right to teach however they please. Therefore, it is essential to instill strong and effective teaching methods early on in their teaching careers. This can be achieved by providing professors teaching workshops and a senior instructor to learn from early on in their career (Jaclyn Stewart, Personal Communication, March 9, 2022). Another solution is the use of standardized slides across multiple course sections. This provides students across multiple sections the same quality of education and benefits newer faculty members who have limited experience creating a teaching plan. The use of these slides serves as a guide and does not inhibit professors' right to teach how they please. Moreover, the introduction of multiple problem sets throughout the semester would take less weight off closed book

examinations and provide students the opportunity to learn from their mistakes throughout the semester.

D. Research Methods

The primary sources of data were collected using a survey through the UBC Qualtrics system. The data collection was completely voluntary and anonymous, and surveys did not contain personal questions which could potentially make the participant identifiable. Forty current and past undergraduate students, who have taken at least one lecture based organic chemistry course at UBC, responded to the survey with their opinions on the quality of organic chemistry at UBC. In addition to surveys, an interview was conducted with Dr. Jaclyn Stewart, who is the associate dean academic of science at UBC. Her experience teaching organic chemistry at UBC provided perspective on the experience professors go through to teach organic chemistry to numerous students at the undergraduate level. The data collected through these methods will be supported by secondary data sources from primary literature on educational psychology and organic chemistry education.

E. Scope of Inquiry

This paper intends to address the following questions:

1) What is the most effective teaching model for communicating organic chemistry, and is its implementation feasible?
2) How accessible are professors and TAs outside of class time, and are students taking advantage of these resources?

3) How do different methods of evaluation affect a student's learning experience in organic chemistry?

By addressing these three questions, it will shed light on any areas of concern regarding the quality of organic chemistry education at UBC.

II - DATA SECTION

A. Participant Demographic

Year Standing	Number of Participants
Year 1	3
Year 2	7
Year 3	9
Year 4	16
Year 5	3
Alumni	2
Total	40

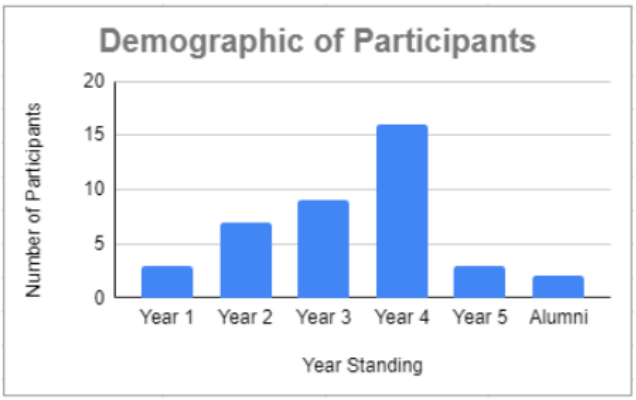


Figure 1 - Demographic of participants for this study, n=40.

The participants of this study included a range of current undergraduate students and alumni. Most participants identified as upperclassmen (Year 3+) or past students, while only 25% of participants were underclassmen (Year 1-Year 2). The participants' gender and other identifiable personal information was not collected for the purpose of this study.

B. Scope of Organic Chemistry Courses at UBC

Course	Percent of Participants (%)
CHEM 123	82.5
CHEM 203	45
CHEM 213	47.5
CHEM 233	35
CHEM 313	32.5
CHEM 330	22.5
CHEM 460	5
Others	7.5

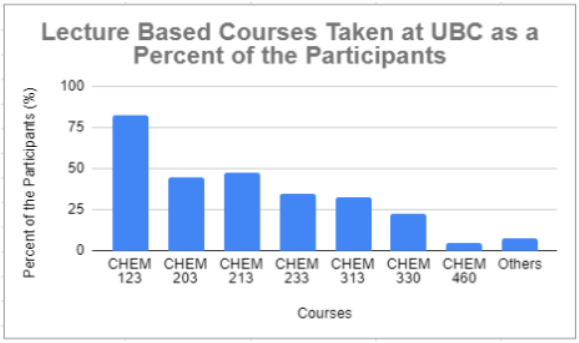


Figure 2 - Lecture based courses taken at UBC as a percentage of participants, n=40.

The participants were asked which classes they have taken during their undergraduate careers at UBC. As shown in figure 2, 82.5% of participants have completed CHEM 123 and approximately 80% of participants have completed some form of second year organic chemistry (CHEM 203, CHEM 213, or CHEM 233). Less than 50% of participants have taken upper-level organic chemistry courses, and many participants stated it is because they are either no longer required for their major, or due to a lack of interest.

C. Assessing the Most Effective Teaching Model for Organic Chemistry

Teaching models differ from professors due to different beliefs and teaching philosophies, which are all protected under the academic freedom act (Stewart, P.C). This act allows professors to instruct a class however they see fit. While some methods of teaching are successful, some may not be effective in the current generation as science evolves. One solution is to offer new instructional staff the opportunity to attend teaching workshops (Stewart, P.C), which would provide a new faculty member the chance to incorporate strong teaching habits into their teaching model. Moreover, new faculty members may be intimidated with developing a lesson

plan for each lecture. An effective solution may be the use of standardized slide decks, that are created by multiple professors. This allows the new professor to focus on communicating the material effectively, without stressing about the content of the class (Stewart, P.C).

Teaching Model	Average Score (1-5)	Preferability amongst students
Lecture + Optional Tutorials - Theory and examples provided in lecture, and a tutorial section for learning reactions and mechanisms (similar to office hours)	1.575	Most Prefered
Theory and examples provided in lecture, and a required tutorial section for learning reactions and mechanisms (similar to traditional tutorial classes)	1.8	
Lecture Based - Less theory and text, and more emphasis on drawing reactions and mechanisms	3.45	
Online + Tutorials - Text, theories, and examples are provided online, and a required tutorial for learning and practicing reactions, and mechanisms (similar to traditional tutorial classes)	3.55	
Lecture Based - Solely of theory, texts, and few examples	4.625	Least Prefered

Table 1 - Summary of findings based on different teaching models. Rankings close to 1 were more favourable to students, and rankings closer to 5 more less favourable.

The use of active learning encourages the student to practice drawing out reactions and mechanisms in a classroom setting, which is essential for learning organic chemistry. Studies have shown that this method of instruction improves a student's cognitive skills and is related to improving a student's attitude and mentality towards the subject matter (Prince 224). Participants were asked about their thoughts on including active learning into the class structure. As shown in table 1, with an average rating of 1.575, the participants wanted to see the introduction of lectures and optional tutorials. Based on student feedback, they have higher preference for more active learning opportunities whether it is in lecture or tutorial classes. In support of active learning, students did not want to see traditional lecture style classes being introduced into organic chemistry. This teaching model which includes theory, texts, and a few examples saw an average rating of 4.625, making it the least desirable teaching method amongst all participants.

One caveat to the introduction of tutorial classes is that it does not promote active learning within lectures. This gives the professor the opportunity to lecture on theory and text as they know the active learning will be completed during a tutorial section (Stewart, P.C).

D. Professor and Teaching Assistant (TA) Accessibility

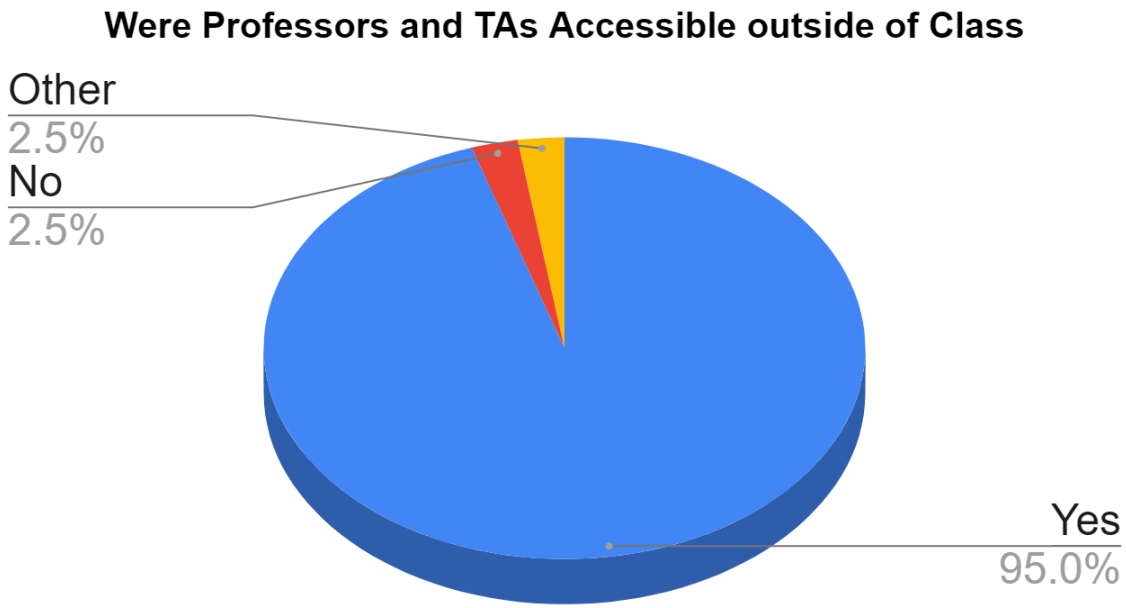


Figure 3 - Accessibility of professors and TAs outside of class time through email or discussion boards

The student and instructor interactions are important for creating a sense of belonging on a campus and school as big as UBC (Stewart, P.C). Based on student surveys, it is apparent that TAs and professors make themselves available outside of class time through discussion boards on Canvas or Piazza, and through email. These discussion boards are a great resource to ask questions regarding the class material, then professors, TAs, or other students can respond with

an answer and promote discussion. Whether students are using these resources is another area of investigation, however professors and TAs are offering their time outside of class to supplement a student's learning experience.

E. Feasibility of Different Evaluation Methods

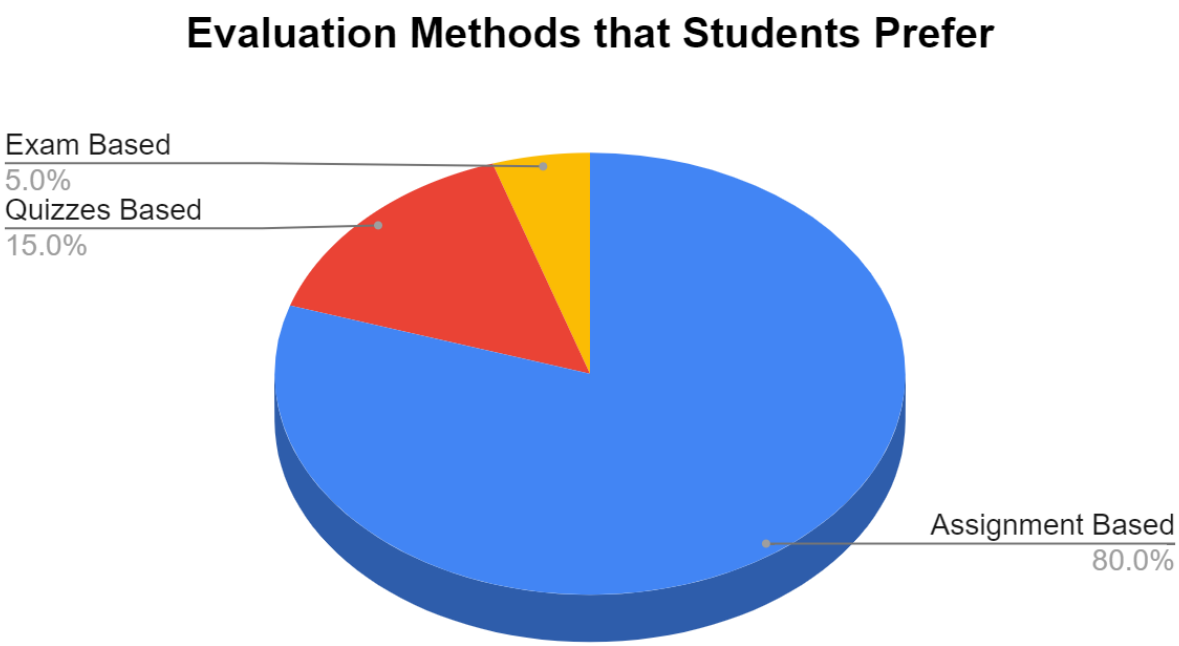
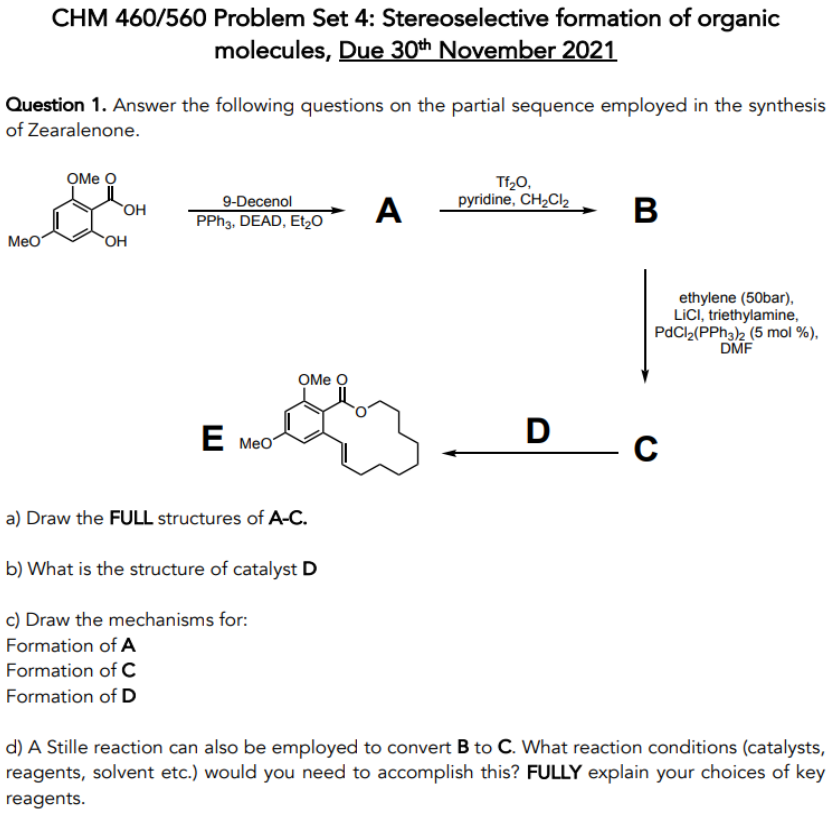


Figure 4 - Preferred evaluation methods amongst participants

The use of closed-book examination is a common evaluation method in organic chemistry classes. This method may not be the most effective evaluation method for a variety of reasons. The use of closed-book midterms and final examinations is not sufficient in providing students feedback throughout the term (Stewart, P.C). There are usually two or three examinations that

make up the entirety of a student's mark, which contributes to increased test anxiety. Test anxiety is attributed to negative physiological reactions and feelings of tension or worried thoughts (von der Embse et al. 485). As a result, a negative emotional and physiological response is generated due to the negative consequences that may result from a poor performance (von der Embse et al. 485). By analyzing figure 4, only 5% of responses prefer examination-based evaluation methods. Most participants prefer an assignment-based evaluation method in addition to closed-book examinations. This method includes weekly or biweekly problem sets that are completed for evaluation, which ensures that the students are keeping up with the material and will provide sufficient feedback on a weekly or biweekly basis. Furthermore, this reduces the emphasis on examinations and provides the student the opportunity to identify holes in their understanding.



CHM 460/560 Problem Set 4: Stereoselective formation of organic molecules, Due 30th November 2021

Question 1. Answer the following questions on the partial sequence employed in the synthesis of Zearalenone.

a) Draw the **FULL** structures of **A-C.**

b) What is the structure of catalyst **D**

c) Draw the mechanisms for:
Formation of **A**
Formation of **C**
Formation of **D**

d) A Stille reaction can also be employed to convert **B** to **C**. What reaction conditions (catalysts, reagents, solvent etc.) would you need to accomplish this? **FULLY** explain your choices of key reagents.

Figure 5 – Example of a problem set used in CHEM 460/560 (Reid)

This method of evaluation is currently implemented in courses such as CHEM 330 and 460 due to their smaller class sizes. This may not be feasible in larger undergraduate classes such as CHEM 123 or 233 where there are over a thousand students enrolled, but another alternative is to have online quizzes or worksheets. The introduction of online quizzes will provide students the chance to practice examination style questions in a low-stress environment, and these problem sets can be automatically graded through the CANVAS system, thus reducing the workload on TAs and professors.

III - CONCLUSION

A. Summary of Results

Students across all year levels shared their thoughts and opinions based on personal experiences with organic chemistry. Students have evolved to prefer a style of teaching that encourages active learning, which involves the use of in class activities such as poll questions. This style of learning is supported by educational psychology studies, which indicate it to be a better method of learning compared to traditional methods. In addition to active learning, students have shown a high preference towards assignment-based assessments compared to closed-book examinations. This method provides consistent feedback throughout the learning process, allowing the individuals to reflect on their successes and mistakes. Additionally, the accessibility of instructional staff and students were assessed. Students indicated that professors and TAs are readily available through email or discussion boards to answer any pressing questions regarding the content in their courses.

B. Interpretation of Findings

To develop a strong foundation in organic chemistry, the material should be communicated in an effective manner that will draw out the understanding from the learner. Participants have expressed their opinions on organic chemistry based on their previous experiences. Many have indicated that the most effective teaching model is the use of examples through active learning techniques such as worksheets and problem sets. This allows students to practice the material and receive sufficient feedback throughout the semester to identify gaps in their knowledge. This teaching model is not currently implemented in any organic chemistry courses at UBC as most classes are solely lecture based with few examples to highlight reactions and mechanisms. On a scale from 1-5 (1 being poor, and 5 being amazing), participants found that the quality of organic chemistry education to be about 3.5/5. This indicates that while the quality of organic chemistry is above average, there is room for growth and improvement.

C. Limitations of the Study

The main limitation to this study was the sample size. There are thousands of students enrolled in undergraduate level organic chemistry courses at UBC every year, and with a limited pool of 40 participants, it is difficult to extrapolate statistically significant data that is representative of the population. Furthermore, educational studies rely on reputable coding schemes such as the State Trait Anxiety Inventory (STAI) questionnaire, which measures anxiety levels in a participant. A questionnaire of this type was not included in the study but should be included in potential studies in the future.

D. Future Recommendations

If your beliefs and interests resonate with the findings of this study, please consider the following suggestions:

1) Promoting active learning strategies in a lecture setting, or creating a tutorial section held by professors or TAs
2) Providing workshops for new professors that promotes good teaching habits
3) Including different types of evaluation methods in courses such as worksheets or online quizzes may aid in student learning

IV – WORKS CITED

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von der Embse, Nathaniel, et al. “Test Anxiety Effects, Predictors, and Correlates: A 30-Year Meta-Analytic Review.” *Journal of Affective Disorders*, vol. 227, 2018, pp. 483–93. *Science Direct*, https://doi.org/10.1016/j.jad.2017.11.048.

V - APPENDICES

A. Survey Questions

https://ubc.ca1.qualtrics.com/jfe/form/SV_eVVBhKRz1Cjk5Ho?fbclid=IwAR1pjCmntfA2fxvgzUS_9_pBWlZgMvlLRXQA7uKQ1BzEZqOUaave1uggIXs

1) What year standing are you currently in?
    a) Year 1
    b) Year 2
    c) Year 3
    d) Year 4
    e) Year 5
    f) Alumni
    g) Other (Please Specify) [TEXT BOX]

2) Please select all the organic chemistry courses you have taken at UBC
    a) CHEM 123
    b) CHEM 203
    c) CHEM 213
    d) CHEM 233
    e) CHEM 313
    f) CHEM 330
    g) CHEM 413
    h) CHEM 460
    i) Other (Please Specify) [TEXT BOX]

3) In general, how do you find the quality of organic chemistry education at UBC? (Rate out of 5)
    a) 1 - Needs to be reformed and improved
    b) 2 - Changes may be necessary
    c) 3 - Average
    d) 4 - Good
    e) 5 - Amazing

4) Was your professor or TA accessible outside of class via discussion boards or email?
    a) Yes
    b) No
    c) Other (Please Specify) [TEXT BOX]

5) Which of the following teaching models would you like to see in organic chemistry? (Rank from most likely (1) to least likely (5))

    [ ] Lecture Based - Solely of theory, texts, and few examples

    [ ] Lecture Based - Less theory and text, and more emphasis on drawing reactions and mechanisms

    [ ] Lecture + Optional Tutorials - Theory and examples provided in lecture, and a tutorial section for learning reactions and mechanisms (similar to office hours)

[ ] Lecture + Required Tutorials - Theory and examples provided in lecture, and a required tutorial section for learning reactions and mechanisms (similar to traditional tutorial classes)

[ ] Online + Tutorials - Text, theories, and examples are provided online, and a required tutorial for learning and practicing reactions, and mechanisms (similar to traditional tutorial classes)

6) What kind of marking scheme would you prefer in an organic chemistry class?
    a) Exam Based - Midterms and final carries the majority of the weight
    b) Assignment Based - Many written assignments (problem sets) throughout the semester, less weight on midterms and final
    c) Quizzes Based - Many in class quizzes throughout the semester, less weight on midterms and final

B. Interview Questions

1) What has your experience been like teaching undergraduate organic chemistry courses here at UBC?
2) From your experience, what is the most difficult thing for students to understand regarding organic chemistry?
3) What are your thoughts on different professors having different teaching models and philosophies? What do you think is the most effective teaching model/style?
4) What are student and professor interactions like based on personal experience and anecdotal experience?

5) What are your thoughts on utilizing a standardized slide deck, or standardized worksheets for large courses, across multiple sections? Rank from 1-5.
6) Would you like to implement a tutorial system for organic chemistry? Yes or No?
7) How effective are the introduction of learning objectives? Is it hard to create specific learning objectives without giving away questions that may be on examinations?
8) What is an effective evaluation scheme? What do you think about examination-based ones compared to assignment-based and quiz-based?
9) How would you rank the current education within organic chemistry? Rank from 1-5, with 5 being excellent, and 1 meaning improvement is required.