

# Turning Lemons into Lemonade

## How a Course-Based Research Experience Facilitated Knowledge and Skill Transfer Between Chemistry and Engineering Students

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## Introduction

### CHM 410-1410 Analytical Environmental Chemistry Research Experience Learning Objectives:

- Provide students with an **authentic learning experience** through legitimate opportunities for decision-making and the potential for failure
- Increase **student investment** in their learning
- **Skill development** in the lab and in project management
- Facilitate **peer-to-peer learning** and cohort building

### Student Population

Semester	Undergraduate Students	Graduate Students (Engineering)	Graduate Students (Chemistry)
Fall 2018	23	10	0
Fall 2017	13	6	3
Fall 2016	20	14	0
Winter 2016	18	7	1

## Example Student Projects

### Is Your Cooking Killing You?

#### Determination of Aldehyde Emission from Heat-Stressed Cooking Oils by LC-MS/MS and LC-UV

Winter 2016; 2 Undergraduate Chemistry Students and 3 Graduate Engineering Students

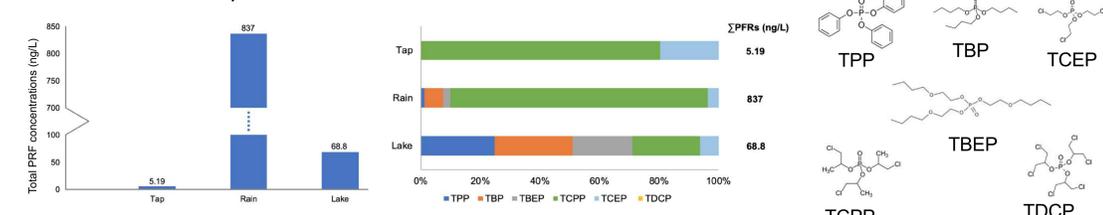


### A Song of Water and Fire:

#### Levels of Organophosphate Flame Retardants in Different Water Sources

Fall 2018; 1 Undergraduate Chemistry Student and 4 Graduate Engineering Students

#### Results from this study:



## Methods

### Winter 2016 Student Survey (results in green histograms)

- A common comment about CHM 410-1410 is that is a lot of work
  - Responses on the course evaluations to the question "Compared to other courses, the workload for this course was..." range from (4.1-4.7)/5
- Given the high workload, in winter 2016 the students were given a survey at the end of term which asked them to reflect on whether the class was "worth it" in relation to a variety of metrics

### Fall 2018 Focus Group (excerpts in blue text)

- Rachel Hems (a chemistry graduate student and previous TA mentor) managed all aspects of the focus group including recruitment, execution and transcription
- On December 20, 2018 three students (one undergraduate chemistry student and two graduate engineering students) took part in the focus group

## Acknowledgments

- Thank you to all of the CHM 410-1410 students, in particular those who undertook the highlighted projects: Jia Bian, Alex Gurizzan, Xinyao (Irene) Gu, Maria Karcz, Suzana Kraus, Ye (Tyler) Yang, Kirsten Yeung, Zhu (Eric) Yu, Chuqiao (Kaya) Yuan, Yu (Ken) Zhao, Xia (Alice) Zhu
- This research was supported by a Teaching Stream Pedagogical Grant from the Faculty of Arts & Science at the U of T to JCD
- All aspects of the focus group were approved by the Research Ethics Board of the U of T (Protocol #: 11853)

## Results

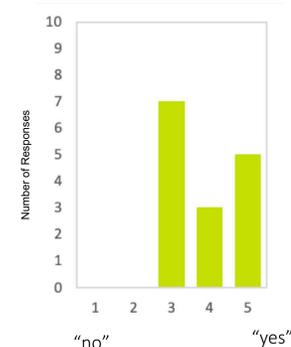
### Authentic Learning & Student Investment

- Since the implementation of the research experience students have expressed increased satisfaction with the class as a whole
  - Responses on the course evaluations to the question "I would recommend this course to other students" increased from (3.5-3.7)/5 before implementation to (3.9-4.3)/5 after
- Exploring a topic of their choosing increased student investment, but was also a source of anxiety as the topic is chosen early in the semester
  - "I think picking your own [topic] is really good and cool... I felt more accountable...like we picked this topic, I hope we can see something from this."
- Students felt the experience was authentic and that they were truly making decisions and dealing with failure
  - "...yeah dealing with bad results also, that was super realistic I think. The not realistic part is that we have a finite amount of time... So in real life we would obviously fix it."

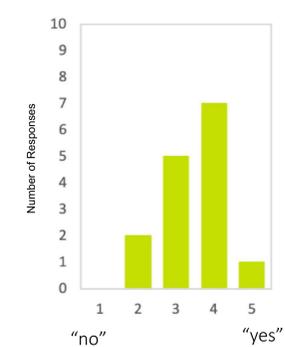
### Skill Development & Peer-to-Peer Learning

- The importance of working intimately with analytical equipment to the student experience was communicated in the surveys
- The importance of working with different students (i.e. chemists and engineers) was a major theme of the focus group
  - "civil engineers...should definitely be [matched] with the chemistry students because it would have been a disaster... and the three other chemistry people in our group were able to take charge of that and we were helping in our own ways because we had a lot of experience in group work and dividing up the work and stuff"
- Peer-to-peer learning was particularly valuable in the lab as the students developed both lab and project management skills
  - "And if somebody would kind of, not master, but got better at a technique we would teach each other how to do things so that we could then delegate. Yeah, it worked really well actually."

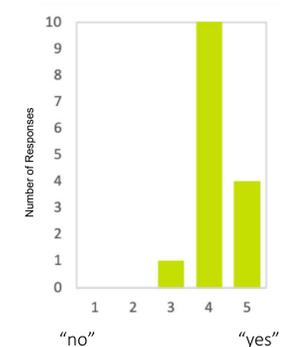
Was all the work in CHM 410-1410 "worth it" overall.



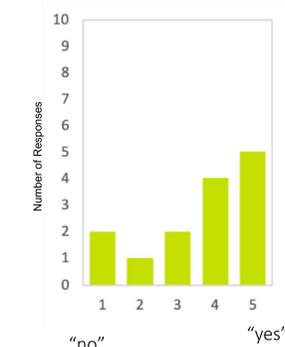
Was "worth it" with respect to the personal satisfaction of completing the final project?



Was "worth it" with respect to the experience of using analytical equipment?



Was "worth it" with respect to the experience of working as a team on the final project?



## Conclusions

- The research experience is successful in providing students with autonomy in the lab, they are making meaningful decisions and feel invested in the work they are doing
- The focus group highlighted the intimate connection between skill development and peer-to-peer learning as the chemists and engineers came to the experience with drastically different skill sets
- Overall the research experience has increased student satisfaction in the class

## Next Steps

- Students expressed difficulty choosing a topic and so we plan to offer additional resources outlining typical "research streams" in environmental chemistry
- We will also provide the TA mentors with additional resources related to project management
- Lab groups have been self-selected in the past but going forward we will organize the groups with the division of experience between chemists and engineers in mind