

TRANSFORMATIONAL STORIES FROM YORK SCIENCE COURSES



science

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INTRODUCTION

In April 2022, the Faculty of Science Teaching & Learning Team invited all Science instructors to share stories of the transformative approaches and strategies they were using in their courses. Some of these stories were inspired by the changes in teaching and learning that were brought on by the COVID-19 pandemic.

The goal of collecting and sharing these stories was for other instructors to learn from each other on how they made transformative changes in their courses, and for students to know how our courses are continually improving. The changes spanned the scope of online learning, overhauling laboratory modules, computational methods, scientific communication, inclusionary teaching practices, anti-racist teaching practices, and/or Indigenous knowledge.

NATS 1720

Light & Sound

Professor Carl Wolf

START FROM THE BEGINNING. TELL US ABOUT THE TRANSFORMATION.

The in-person labs in NATS 1720 were turned into at-home activities for the duration of the remote-learning period, that is for the 20-21 and 21-22 academic years.

WHAT MADE YOU UNDERTAKE THIS?

With the pivot to remote learning it would have been easy to just drop labs entirely. However, it is my belief that NATS students benefit greatly from experiencing some phenomena with their own eyes (and ears in this case). It's the difference between being told that something happens a certain way and discovering it for yourself.

WHAT HAPPENED NEXT?

The first step was to brainstorm and identify meaningful activities that could be performed by students using only materials reasonably available to everyone at home. It quickly became apparent that the most useful and readily available piece of equipment was the computer on which students would attend class. More specifically, the computer's sound recording and reproduction capabilities would allow new activities to be created. (This also led to a decision to refocus the remote version of the course on "synthetic" applications such as sound recording and reproduction and photography, instead of topics more suited to a "live" setting such as room acoustics.)

Three of the sound-related labs ended up making use of the Audacity software suite whereby students could produce the necessary sounds at home and use their own ears as "detectors". The remaining labs made use of freely-available online simulations (from the PhET and Compadre sites) to support activities to explore diffraction & interference (of sound and light), the optics of a camera (usually done with real lenses), and the optics of the eye.

Where feasible, students were asked to solve a practical problem, for example working out the parameters of a corrective lens for their "distressed" model eye.

WHAT ELSE WAS THERE TO IT? ANY ROAD BLOCKS?

One challenge was heterogeneity of student computing platforms. Some students had difficulty running Audacity (notably on Chromebooks), others had smaller screen sizes that made the suggested settings for the virtual optical bench a bit problematic. But no serious issues came up that were generalized.

After the first year it was apparent that asking students to work out a corrective lens for their model eye was too challenging (and impossible on some platforms), so that part was dropped.

HOW DID IT END?

Students seemed reasonably happy with these activities, even though they probably took up more time than a traditional lab would have. With a return to in-person labs expected, some elements of the remote activities will be incorporated, notably the use of Audacity in the sound perception lab. Other elements may be folded into assignments where appropriate. But the experience also revealed that for the topic of optics a virtual optical bench isn't nearly as good as the real thing, but it may be a valuable add-on.

NATS1720

Light & Sound

BEFORE

- Sound perception lab using single tone generator to explore hearing threshold.
- Vocal formants lab using specialized software to record and analyze sounds of speech.
- Eye lab wherein students (with the aid of a partner) map their own blind spot and region of foveal vision.

AFTER

- Sound perception lab using prepared Audacity audio files to explore masking and virtual pitch.
- Sound synthesis lab wherein students use Audacity to create a new sound using what they have learned in class.
- Eye optics lab in which students build a model eye on a virtual optical bench and then “distress” it to render it, say, myopic.

BIOL2040

Genetics

START FROM THE BEGINNING. TELL US ABOUT THE TRANSFORMATION.

We completely redesigned the 2000-level introductory molecular genetics course (BIOL2040) to emphasize the multifactorial nature of phenotypes and variation within populations, rather than simple "Mendelian" genetics. We also solidified the flipped, active learning approach we had both independently been moving towards in previous semesters and committed to using only instructor generated or otherwise "free" course material (i.e., no textbook).

WHAT MADE YOU UNDERTAKE THIS?

From our previous experiences with the course, we knew that students often entered BIOL2040 with the misimpression that multifactorial phenotypes (often referred to as "non-Mendelian") were the exception, when in fact the opposite is true. We also noticed that many students expressed a type of genetic determinism (the belief that all biological traits are attributed, almost exclusively, to gene function) that caused them to struggle with understanding environmental and epigenetic influences on phenotypes. It also seemed that the "typical" approach to the teaching of lower-level genetics reinforced these misconceptions.

The typical approach to teaching genetics tends to focus on simple "Mendelian" genetics with only limited discussion of the multifactorial nature of phenotypes, usually due to the belief that we must first establish student comprehension of simple (i.e., Mendelian) genetics before introducing them to the complexity of the more common multi-factorial phenotypes.

Along with our own experiences evidence from research in genetics education suggests emphasizing Mendelian genetics can reinforce a simplistic and naïve understanding of phenotypic variation, inadvertently encouraging students to think deterministically and some have suggested that this in turn bolsters belief in genetic essentialism, which underpins racist thinking (Donovan et al. 2020; Donovan & Nehm, 2020; Jamieson & Radick 2013, 2017; Dougherty, 2009).

Teaching using an approach that emphasizes gene-environment interactions, rather than the typical emphasis on simple "Mendelian" genetics has also been shown to improve understanding of the complexities of genetics as well as reducing belief in genetic essentialism (Donovan et. al. 2020).

We, therefore, wanted to transform BIOL2040 to provide students with a more authentic understanding of phenotypic variation, which would serve not only as a strong foundation for future courses but also reduce deterministic (and consequently genetic essentialist) thinking.

WHAT HAPPENED NEXT?

We started meeting in mid-2020 to discuss our goals for the course redesign and our general thoughts on structure, and to gather and share resources. We decided early on that the optimal course structure would be "flipped"; with pre-class "prep" material focused on basic concepts (e.g., review, definitions, and such) and class time used for small group activities and discussion. We also decided on a general assessment structure using mainly in-class activities and weekly short answer questions (instead of midterms/finals).

By Winter 2021 we were meeting weekly to work on the new course structure. We started with determining the overarching and topic-level learning outcomes and drafting a "topic flow" document. we began to build a detailed week-by-week breakdown of topics, prep material needed and ideas for in-class activities.

We then focused on designing the course material, especially the in-class activities. Most activities incorporated examples from current genetics research or "real world" examples (i.e., phenotypes students would be familiar with). We diversified the type of activities and the material provided in line with UDL practices. Almost all activities were designed from scratch.



Tanya Da Sylva

BIOL2040

Genetics

We also collated and where necessary created “prep” material. Where possible we used material we had created for previous iterations of the course, and open access resources rather than creating new material.

WHAT ELSE WAS THERE TO IT? ANY ROAD BLOCKS?

As the course delivery format for Fall 2021 was still being determined as we were redesigning the course, we decided to design in-class activities such that could be completed in small groups both online (synchronous) or in person. Activities were distributed to students using Google docs and other online formats (e.g., Microsoft forms). We decided to use a combination of Crowdmark and Zoom polls to assess students’ participation in activities and their learning progress. We also used Crowdmark for our weekly short answers and other marked assessments.

Due to equity and access concerns with remote learning we decided to also offer an asynchronous class activity option. This posed several challenges. We assumed most students that did not participate synchronously would be working through activities on their own (instead of small groups during class). Students working asynchronously would also be missing the discussions before and after the activities, as we weren’t releasing class recordings until after the asynchronous activity deadlines.

Therefore, we designed modified activities that met the same learning objectives as the activities done during class but in a format more conducive to individual learning and the asynchronous activities needed to include any key discussion points or “take-up” of material that we had planned for class. Essentially, we designed two courses – an asynchronous course and a synchronous course.

This proved too time consuming, and we are unlikely to offer such an extensive asynchronous option in the future. Instead, we will likely allow students who cannot attend class to access and complete the in-class activities during a limited time window. We will direct students to watch the class recording for the minimal instructional content instead of designing a whole asynchronous “lesson”.

It took a large amount of time to generate all of the new material being created (e.g., prep material, activities, assessments, and so on). However, now that the structure is in place, we anticipate generating activities and assessments will go more smoothly in the future. We also knew we would be sharing resources with the Winter and Summer 2022 instructors, so material and activities were made to be reusable or easily modifiable. The use of short answer questions, rather than multiple choice, makes rewriting graded assessments easier as well. The course redesign has been successfully carried forward in the Winter and Summer offerings.

HOW DID IT END?

The final summative assessment showed students had, in general, improved in their writing and reasoning skills. Most students also seemed to embrace a more complex and authentic view of genetics.

Over the term students also completed validated pre-/post-term surveys (Carver et al.; Donovan, 2017) regarding genetic determinism and essentialism, as well as class activities designed to assess their understanding (and learning progression) of the multifactorial nature of phenotypes, inheritance, and population level variation.

Quantitative and qualitative analyses of responses to these surveys and activities are underway. This analysis will help us to better understand student comprehension and misconceptions regarding the role of genetics in phenotypic variation, and students’ levels of belief in genetic determinism and essentialism.

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Genetics

BEFORE

- Focus on Mendelian genetics
- Cost to course materials (ie. textbook)
- Traditional classroom experience

AFTER

- Emphasis on multifactorial nature of phenotypes and variation within populations
- Free course materials (open access and instructor generated)
- Flipped classroom experience with pre-class “prep” materials focused on basic concepts (ie. review, definitions), and class time used for small group activities and discussion
- Most examples came from current genetic research or “real-world examples”

MATH 1505

Mathematics for the Life and Social Sciences

START FROM THE BEGINNING. TELL US ABOUT THE TRANSFORMATION.

Math 1505 was a required six credit course for undergraduate students studying either biology, psychology or kinesiology. Students were advised to take this course in their first year of study, but often left it until much later – usually to their detriment. The course had a poor reputation due to high failure/withdrawal rates and low student satisfaction. The anxiety of an average student taking the class was very high, often leading to a self-fulfilling prophecy of failure. Part of the effort to improve the student experience and chance of success was to turn 1505 into two three credit courses, Math 1506 and 1507, and to accompany that split with tutorials as a way to supplement learning the material in the course.



Amanda Chow

WHAT MADE YOU UNDERTAKE THIS?

Many students who took the course were fearful of mathematics and lacked the background mathematical knowledge needed to successfully complete the course. Consequently, Math 1505 often had high withdrawal and high failure rates. Many students who eventually completed and passed the course “squeaked by” and often did not learn the necessary content. There are also many students who re-took the course numerous times, which lead to a general sense of low morale amongst the student population in the course. The math/stats department wanted to improve student performance in this course and boost the course’s reputation by dedicating significant faculty effort.



Andrew McEachern

WHAT HAPPENED NEXT?

Amenda began the process, consulting with key stakeholders:

- meetings with the registrar’s office to reduce financial barriers
- communications with the textbook author to revise the textbook to suit the learning needs of our students
- interviews with students lead by our faculty of science educational developer
- discussions about approaches to reduce withdrawal and failure rates were undertaken with the Faculty of Science Associate Dean of Students, department chair, past and present Math 1505 instructors, academic advisors from both health and science, undergraduate program directors, and professors in biology, psychology and kinesiology.
- during candidate interviews for a tenured track teaching stream position in our department, there was emphasis given on who had the experience and energy to revitalize Math 1505.

All of this occurred during a span of about 3 years, and the project was passed to Andrew, who would take over as coordinator for the course in September 2020.

Once the split of the course happened, there was also significant faculty time and energy devoted to developing free online notes, tutorials for the students, and online tests to be taken through eClass.

MATH 1505

Mathematics for the Life and Social Sciences

WHAT ELSE WAS THERE TO IT? ANY ROAD BLOCKS?

Change does not occur overnight. It requires patience, trial and error, foresight, resources and teamwork. We had to be flexible and adapt when changes occurred (e.g. someone new became the department chair or associate dean, etc.). The pandemic and switch to online teaching also impacted the changes made to Math 1505.

Once everything moved to remote teaching, significant changes happened, mostly as a result of a lackluster first offering of Math 1506 and 1507 during 2020-2021. Many of the teaching and testing strategies that were to be implemented during the in-person offering were attempted in the remote offering by and large failed miserably. The eClass forums as an attempt to get students involved were also a dismal failure. The tutorials were originally intended to be in-person experiences, but the pandemic forced a change and it was decided to go with asynchronous learning modules. The expensive textbook was replaced with free online resources, but the organization of that information was lacking and students were dissatisfied with the difficulty of accessing the required information. After taking some summer courses from the Teaching and Learning Center, it was decided another massive overhaul to the course structure was necessary.

The partially filled notes that students would fill out during lecture and the asynchronous tutorials were kept and improved, but the style of testing changed for 2021-2022. In each course, 1506 and 1507, a mastery style grading scheme was adopted for three tests in each course. A given test would be open for a week, and a student could attempt a randomized version of that test – with questions and numbers drawn from a large bank of questions - as many times as they liked, keeping the highest grade they had earned. It provided a low-stakes environment in which the students could see what they did not know, seek help in any manner they found comfortable, and then attempt the test again once they felt ready. Student feedback was extremely positive about this style of testing, and the reported anxiety was extremely low. This style of testing was kept for the in-person offering of Math 1507, which allowed class time to be devoted to learning and positive instructor-student interactions.

The iterative learning involved in the mastery style grading only really worked because of the second major change to the course, which involved the ability to get help from the instructor, TAs, and other students. A Discord channel was created for the most recent offering of 1506 and 1507. Student participation was breathtaking. The quantity and quality of the student-to-student interaction was, for the most part, very positive. It allowed students and TAs to work at all hours of the day or night, something they all found very appealing. To put a numerical touch to it, the server opened September 8th 2021 and closed April 27th, 2022. There were 1085 active users by April 27th, and 29812 messages had been exchanged on the server – fewer than 2500 of those messages were written by the coordinator.

HOW DID IT END?

At this point there is still some fine tuning of the notes, tutorials and tests that needs to be done. The changes and improvements to this course are ongoing as student needs evolve.

MATH 1505

Mathematics for the Life and Social Sciences

BEFORE

- Math 1505, six credit course
- 180 minutes of lecture time per week
- Peer discussion forum via Moodle had little participation from students.
- For students who wanted to switch out of math 1505 and into math 1510, which teaches prerequisite knowledge for Math 1505, there was a financial fee associated to this.
- Math Background tutorials, which were review sessions for 16 hours over one week in August to refresh students' trig and algebra skills prior to starting their first university level math course. There were no grades or credits assigned to Math Background tutorials.
- No teaching stream faculty taught this course. Few faculty wanted to teach the course because of the negative reputation of the course.
- The textbook cost was about \$100 per student and applications were mostly biology focused. More than half the content in the textbook was not used, and topics in statistics were not adequately presented.
- No easy way to communicate student needs and concerns with faculty. Student satisfaction and morale extremely low.

AFTER

- Split into two three credit courses called Math 1506 and Math 1507. This allowed those struggling to not lose two semesters (only one).
- 180 minutes of lecture time per week, asynchronous tutorials for math 1506 and 1507, and a Discord channel which allowed for more contact time between student and teachers, as well as peer-feedback opportunities.
- Peer discussion forum via discord has extraordinary participation from students
- The registrar's office agreed to remove this fee; however, few students took up this opportunity as taking Math 1510 would mean they would fall behind on their program requirements.
- Tutorials are asynchronous opportunities for students to brush up on their skills and expand their learning about a given topic in the course.
- In the last five years, the course coordinator is a teaching stream faculty with considerable teaching experience and motivation to making positive changes to the course.
- The expensive text was replaced with open education resources, such as partially filled notes and free textbooks. During the last offering these resources were effectively organized to promote student learning.
- The Discord channel allowed students to freely discuss their concerns and needs with faculty, TAs, and with each other. The resulting student satisfaction seems to be far higher, as evidenced by anecdotal and instructor evaluation results.

PHYS 1800

Engineering Mechanics

START FROM THE BEGINNING. TELL US ABOUT THE TRANSFORMATION.

In Fall 2021, PHYS 1800 labs were approved to be in-person, however Lassonde desired students to have the flexibility to seamlessly switch between the in-person and remote lab formats. Lassonde therefore wanted the remote and in-person lab exercises and experience to be as similar as possible.

Existing remote versions of PHYS 1800 (from Fall 2020) did not correspond well to our existing in-person labs (pre Fall 2020).

We needed to transform the lab experience into a super flexible blended format.

WHAT MADE YOU UNDERTAKE THIS?

This originated through a request from Lassonde.

WHAT HAPPENED NEXT?

We thought about different ways to implement remote labs. Remote implementations elsewhere in our department had remote students watch a video and then download data (sometimes unique) for analysis. These implementations would give students the same data analysis exercises, but remote students would lack any experimental technique.

Our model for remote labs had students following the same manual as the in-person students, however, for each data collection step, multiple videos with associated data would be presented to the students. Each of the videos showed data being collected, sometimes correctly, but often incorrectly. Remote students had to comment on the experimental technique of each video, and determine which video /data to use to perform their data analysis for the labs.

Just like the students in the class who have to pay special attention to the procedure and are often never quite sure they are performing the experiment directly, the remote students. We wanted a way to bring that experience

Remote students had a choice of completing the labs entirely on their own, or joining a TA-led zoom session during their normally scheduled lab time.

WHAT ELSE WAS THERE TO IT? ANY ROAD BLOCKS?

We wanted remote students to have to pay very careful attention to the videos of data collection to observe which video demonstrated the correct technique. For some experiments, it was challenging to have a variety of videos which didn't obviously demonstrate bad technique. This serendipitously led us to having sometimes two correct videos (out of 4 or 5) with associated good data. This challenged the students to look harder into the videos, and to discuss during their remote lab sessions.

HOW DID IT END?

It worked surprising well. Many students commented that they enjoyed the remote labs more, other students (roughly one third) consistently attended the labs in-person thereby signaling their preference for the in-person experience.

All in all, students were well served depending on their preference, the learning experience between remote and in-person labs was as similar as possible. There was no observable grade difference between the in-person and remote labs.



Matt George

Engineering Mechanics

BEFORE

- Remote labs a combination of simple home-built experiments and online simulations.

AFTER

- Remote labs mimic in-person experience by following the in-person lab manual along with a series of data collection videos and associated data for each data collection step.
- We hope to use these remote labs in the future for student who are absent for an in-person lab.

MATH 6650

Introduction to Statistical Data Science



Jairo Diaz-Rodriguez

START FROM THE BEGINNING. TELL US ABOUT THE TRANSFORMATION.

Data Science is a new area of knowledge that is taking more relevance in today's data-driven world. Keeping updated with modern trends and requirements is a challenge to university courses.

WHAT MADE YOU UNDERTAKE THIS?

Traditionally, Statistics courses are taught based on R programming, but work profiles are asking for modern programming languages such as Python, and traditional data base languages such as SQL that are not taught to Mathematics or Statistics students.

WHAT HAPPENED NEXT?

The new course is a case-based course developed totally on Python programming, and with some introduction into SQL scripting. The focus is also on real data problems with real life questions. Students are guided through cases with real data to give a solution at the end of each lecture.

WHAT ELSE WAS THERE TO IT? ANY ROAD BLOCKS?

The main roadblock is the lack of previous Python knowledge from students coming from Math & Stats background.

HOW DID IT END?

Students were very satisfied, they learn Python, SQL and a lot of useful techniques and tools to face data problems that they can encounter in future careers as data scientists.

MATH 6650

Introduction to Statistical Data Science

BEFORE

- R programming language
- No database instruction
- Review of traditional Statistical methodologies
- Introduction to theory in Statistics and Data Science

AFTER

- Python programming language
- Introduction to SQL and database queries
- Real life-based data with questions and solutions. Students can find solutions to real problems that they might face on their future jobs.
- Simultaneous learning of theory and practical solutions through real life problems.

NATS1830

Mysteries of Everyday Materials

START FROM THE BEGINNING. TELL US ABOUT THE TRANSFORMATION.

When I joined York University in 2018, NATS1830 was one of the courses that was available to teach (it was an older NATS course that had not been offered in many years). The description indicated the course focused on using a Chemistry lens to explain the how everyday materials worked. I redesigned the course to include materials that I thought students would be particularly interested in learning about (e.g. batteries, sunscreen, fireworks, etc.) and the first year I taught it (2018-2019), I ran it as a strictly lecture based course. At the end of the year, I generally received positive feedback from the students, but I knew this course had much more potential. With the help of the NATS Director Dr. Julie Clark, I wrote up a proposal to add 10 laboratory experiments to the course that were based on lecture concepts. For example: in lecture students learn about how sunscreen protects our skin from harmful solar radiation, and in a supplementary laboratory experiment, students test sunscreens of various brands

and SPF values for their ability to absorb UVA and UVB radiation using a UV-vis spectrophotometer. I ran the laboratory experiments for the first time in 2019-2020 and overall they were a success; student feedback indicated they enjoyed the opportunity to be a “scientist” and apply what they learned in lecture.

With the success of the labs, I made one additional transformation to the course in 2020-2021. In other NATS courses that I run, I offer a pseudo-flipped classroom teaching style (in alternating weeks throughout the course, one of the 1.5-hour lectures is used to learn new concepts and the second 1.5-hour lecture is used to complete an in-class case study or activity). I applied this teaching style to NATS1830 which provided students an opportunity to work together on a case study in class, have an opportunity to ask myself questions about class concepts and apply what they learned in the previous lecture.

In the end, I transformed a class that was solely lecture-based into one with 10 laboratory experiments as well as in-class case studies held throughout the course. The transformation allowed a greater level of student engagement with the material and offered an experiential education component to NATS1830.

WHAT MADE YOU UNDERTAKE THIS?

When I first taught NATS1830 in 2018-2019, I was pleased with the lecture concepts that I chose to include in the course, but I was not happy with the lack of student engagement with the material. Being that this course would be the only science course many of my students would take in their undergraduate career, I really wanted them to have a meaningful experience rich in experiential opportunities. Therefore, I started by adding a laboratory component to offer the experiential component, and later included the pseudo-flipped classroom approach to improve engagement during lecture.

WHAT HAPPENED NEXT?

Laboratory experiments were offered in the 2019-2020 academic year (will now be offered in 2022-2023 that in-person learning has resumed) and the pseudo-flipped classroom style has been offered since 2020-2021.

WHAT ELSE WAS THERE TO IT? ANY ROAD BLOCKS?

The major roadblock was getting all 10 laboratory experiments written, lab equipment purchased and the laboratory room ready for the launch of the labs in September 2019. Luckily, I work with an amazingly talented laboratory technician Uzma Muzamal who helped gather the equipment and material. Over the summer 2019, Uzma and I ran a test version of every laboratory experiment that I had written and made necessary modifications to ensure they ran smoothly for the students.



Stephanie Pugliese Domenikos

NATS1830

Mysteries of Everyday Materials

HOW DID IT END?

In the end, I am very pleased with the current NATS1830 course. Overall, I think it has improved significantly since the first time I ran it and I believe the transformation has enhanced the student's experience. I am still writing new laboratory experiments and case studies to improve the versions I currently have, but I now have a version of the course that I am very happy and proud to offer the students in September.

BEFORE

- Lecture-based course
- No experiential learning

AFTER

- Pseudo-flipped classroom course
- 10 laboratory experiments

MATH 1013

Applied Calculus I



Andrew Skelton

START FROM THE BEGINNING. TELL US ABOUT THE TRANSFORMATION.

MATH 1013 is a core introductory calculus course for a variety of science and engineering majors. Students face enormous challenges in the transition from high school to university, but I firmly believe that there is a lot we can do to help ease that transition.

The gold standard of transition programming is the First-Year Seminar, a credit course that teaches students university success strategies such as learning skills, study skills, numeracy skills, and life skills, but such courses are not common practice in Canada.

An alternative delivery model for FYE programming is to integrate the content into the academic curriculum, but this comes with challenges such as buy-in and loss of efficacy. Over the last three years, I have introduced the instruction of teaching and learning skills into the academic curriculum of this course.

WHAT MADE YOU UNDERTAKE THIS?

As a former high school teacher and frequent instructor of core first year courses, I often get asked to speak to teachers about the transition from high school to university.

The most common question is “what are our students missing”. I think they are expecting to hear “trig” or “logarithms”, or another content area, but my answer is usually independent skills and an ability to set goals in learning skills, life skills and study skills.

I wanted to put my money where my mouth was and introduce these skills into the curriculum.

WHAT HAPPENED NEXT?

This was year three of a multi-year project. In years 1 and 2, I had students work on researching a variety of student skills, I introduced them into my section of the course and collected and analyzed the data. In year 3, I created open-source modules that were used in all six sections of the course.

The main questions that were asked during this entire process were: What does it take for instructors to adopt these materials in their courses, what does it take for students to complete them, and can they still be effective?

From the student perspective, the benefit (skills improvement, academic success, and direct academic reward) must be balanced with the cost (time, effort, and motivation).

From the faculty perspective, the benefit (retention and improved student outcomes) must be balanced with the cost (workload, motivation, perceived sacrifice of course content and resource cost).

WHAT ELSE WAS THERE TO IT? ANY ROAD BLOCKS?

The hardest part was developing resources that would be adopted by instructors with different teaching styles. Part of the process was a faculty survey to learn more about their preferences and needs and what would likely be adopted. Any intervention will be unsuccessful if it doesn't end up in the hands of the students.

HOW DID IT END?

It ended with the publication of 15 open-source learning modules that can be dropped into any course, plus continued funding to develop additional modules this summer.

MATH1003 Applied Calculus I

Currently available modules: managing academic stress, test writing strategies, academic honesty, chunking, study sessions, exercise solving, grade calculation, growth mindsets, learning by teaching, managing perfectionism, procrastination, professional communication, spaced retrieval, staying on task, values affirmation. Module modules to come!

BEFORE

- Course Content: Standard calculus course sequence
- Assessment: 3 tests + participation + final exam
- Instructional Design: synchronous

AFTER

- Course Content: Standard calculus course sequence + instruction in learning/life skills
- Assessment: 10 quizzes + 4 assignments + learning/life skills reflections + participation + final exam
- Instructional Design: flipped (2 asynchronous + 1 live session per week).

BIOL1001

Evolution, Ecology, Biodiversity & Conservation

START FROM THE BEGINNING. TELL US ABOUT THE TRANSFORMATION.

Please note that most of the descriptions below refer to changes that were implemented for the Fall 2020 and Winter 2021 terms, with some adjustments/refinements made in the second pandemic year based on the experience from the first pandemic year.

For BIOL2050 and NATS1550 I flipped the course, so students were exposed to the material prior to class through short videos and assigned readings and were then given the opportunity to assess their learning with in-class activities and to ask questions. BIOL1001 already had a largely flipped course structure, to which I added additional videos. I also took the opportunity to update and streamline content, update learning outcomes etc. where needed, including switching to a new textbook that better matched the active, applied learning approach for BIOL2050.



Bridgit Schwartz

For all three courses, I changed the format to a weekly module structure, changed the assessment structure and implemented additional UDL (Universal Design for Learning) elements. The new weekly modules consisted of the pre-class videos and readings, Learning Outcomes to guide student learning, pre-class quizzes (low stakes, two attempts), in-class activities (practice questions, case studies etc.), and a summative assessment in the form of a weekly short-answer question. In-class activities were highly interactive, with students working in teams and at least 50min per week reserved for student Q&A sessions. The weekly assessment questions, the most significant change to the assessment structure, emphasized application and problem-solving and replaced midterms in these courses. Students also completed a final summative assessment in the form of an open-book, take-home final exam (online) with short-answer questions that were similar in style to the weekly short-answer questions. BIOL2050 and NATS1550 also had a podcast team project.

- I already recorded my lectures prior to the pandemic, and continue to do so. New or expanded efforts to make the courses more equitable and accessible included:
- Offering an asynchronous alternative to the in-class activities (e.g. as a discussion forum).
- Providing at minimum multiple days to complete any of the assessments, including the final exam.
- Dropped elements so students could miss the occasional assessment without penalty (e.g. only top x of quizzes/questions count)
- Grace days (limited number of days/times certain assessments could be handed in late)

WHAT MADE YOU UNDERTAKE THIS?

Some of the changes I had already planned to make (shift to flipped structure, more UDL elements to increase equity), though I had planned to make them more gradually and the pandemic made them more urgent. Others, such as the weekly module structure and assessment changes, were prompted by the pandemic/shift to online teaching.

The pandemic and associated shift to online teaching meant a greatly increased need to keep students engaged, motivated and connected – to the course, me and their peers. Since learning has important social aspects and peer learning has been shown to be very effective, I wanted to ensure that encouraged interaction and engagement in collaborative learning. Having the interaction between students also seemed very important from a social and motivation aspect, especially during the pandemic.

I attended several courses, conferences and workshops on online learning and course design and advice from experienced online educators inspired many of the course design elements, e.g. the recommendation from experienced online educators to move to more frequent, small-stakes assessments rather than few, high-stake ones, along with the inability to hold traditional exams without exacerbating equity issues, prompted the major change in assessment strategy.

BIOL1001

Evolution, Ecology, Biodiversity & Conservation

The pandemic situation, with many people experiencing illness, increased care-giving duties or greater need to support family members, and other hardships also necessitated greater flexibility and accessibility. Therefore, my aim was to design a course where students would have a high amount of flexibility in completing course elements and that would accommodate many different life circumstances, so most students would not need to ask for personal accommodations, extensions or other exceptions, and feel compelled to reveal personal circumstances to me.

WHAT HAPPENED NEXT?

Student buy-in was generally very high. Student motivation and synchronous class attendance were especially high during the first year of the pandemic (despite class attendance being optional, but of course strongly encouraged!). Many students were hugely appreciative of the flexible options throughout the term and felt that these greatly helped them to succeed. Surveys and student comments also indicated that the vast majority of students felt that the weekly modules and assessment structure helped keep them on track and helped their learning. Several commented that the weekly short-answer questions were particularly conducive to thinking more deeply about the material, compared to studying for a midterm that would often involve last-minute cramming without really understanding the material. Many also commented that the interactive nature of the course, with the in-class activities and peer learning helped them learn and stay motivated. Several students also commented on the social aspect and that the breakout room sessions were particularly helpful during the pandemic as they facilitated contact to other students.

WHAT ELSE WAS THERE TO IT? ANY ROAD BLOCKS?

I made the change to all three courses for the first fully online pandemic term, which was extremely exhausting and challenging due to the need to create all the videos, quizzes, in-class activities, weekly questions etc.. Another issue were student perception on grades. Many students were concerned when they received a low grade on one of the weekly questions (despite doing very well overall), perceiving this as representative of a midterm grade, rather than one question on a midterm, but improved communication around keeping perspective and clarifications around the marking scheme helped improve this to some degree. A few students felt there were too many assessments and expressed preference for a more traditional system with fewer high-stakes assessments, but this was very rare.

HOW DID IT END?

I would not say it has ended, since improvements to courses are an ongoing process. So far, outcomes have included: Significantly higher course grade averages and overwhelmingly positive feedback on surveys about the course assessment structure, as well as unsolicited student comments on the helpfulness of the assessment structure and incorporated flexibility. For BIOL1001, instructors from other sections have now implemented the weekly short-answer questions and additional UDL/flexibility elements, including in the two sections that were taught in-person in the last term, and instructors for a different course also implemented a weekly short-answer question assessment modelled on the one I used in my courses.

Evolution, Ecology, Biodiversity & Conservation

BEFORE

- BIOL2050, NATS1550: Primarily lecture-based with interspersed activities.
- Assessment heavily exam-focused, with in person, closed-book, time-limited exams (midterms and final exam, relatively high-stakes)
- Lecture recordings, limited grace days in two of the three courses. Participation points only if attending class live.

AFTER

- Fully flipped with short pre-class lecture videos and/or readings, pre-class quizzes and collaborative in-class activities, case studies, practice questions etc.
For BIOL2050 & NATS1550: major update to content, learning outcomes; for BIOL2050 switched to a different textbook that better supported the active course structure and focus on knowledge application with online data, case studies and modelling exercises.
- Assessments broken down into smaller, lower-stakes components associated with weekly modules (quizzes, weekly short-answer questions). Open-book, focused on problem-solving and application with several days to complete.
- Additional grace days, dropped components, multiple days to complete assessments, option to complete class activities asynchronously.

BIOL3001

Behavioural Ecology

START FROM THE BEGINNING. TELL US ABOUT THE TRANSFORMATION.

I took the hands-on Urban Watersheds and Biodiversity in-person field course, BIOL3001 3.0 online, converting it from a two-week, Monday to Friday 08:00-5:30 pm field course to a 9 hours/week for 6 weeks, online course in Summer 1 Term 2020, when the in-person field course was cancelled due to the pandemic:

<https://biology.info.yorku.ca/category-a-field-courses-exclusively-for-york-u-students/>

WHAT MADE YOU UNDERTAKE THIS?

Between January 2020 and late February 2020, well before the March 13, 2020 provincial lockdown, the university representatives of the Ontario Universities Program in Field Biology group, 16 universities that share spaces on our collective field courses, pre-emptively cancelled 30 in-person field courses.



Dawn Bazely

WHAT HAPPENED NEXT?

I had to design a curriculum that could be done by students at home, using their Kitchen laboratory and their gardens or parking lots. I remembered my own childhood science activities and found lots more on the internet. See my recipe for this at JoVE blog:

<https://www.jove.com/blog/educator-blog/dr-dawn-bazelys-top-5-tips-for-building-a-remote-science-lab-kit/>

I also designed an inexpensive at-home lab kit (around \$20) that was shipped to students who were relying on the summer field course to complete their degree requirements, so that they could convocate with BSc degrees in Fall 2020.

WHAT ELSE WAS THERE TO IT? ANY ROAD BLOCKS?

I phoned lots of friends who are fabulous at science pedagogy and all-round excellent teachers, and people, to give guest lectures on zoom. Roadblocks?

Glitchy internet because everyone was working from home!

HOW DID IT END?

Twenty-six students did hands-on science (from ornithology to soil science to studying pollen) at home, and then collaborated on independent research projects that they designed. Everyone passed and was pretty happy! I was tired.

Behavioural Ecology

BEFORE

- In person field courses
- Prof. Shoshanah Jacobs and her Master's student, Bailey Bingham were researching the pedagogical benefits of field courses, and other independent research undergraduate courses, charting their benefits

AFTER

- Virtual field courses
- Prof. Jacobs, Ms. Bingham and Ms. Simone Boivin (undergraduate honours thesis student), interviewed the virtual field course students and found that many of the outcomes of in-person field courses WERE achieved in this course:

See video here:

<https://biology.info.yorku.ca/category-a-field-courses-exclusively-for-york-u-students/>

CHEM 3000

Experimental Chemistry

START FROM THE BEGINNING. TELL US ABOUT THE TRANSFORMATION.

Developing a Framework for Third-Year Chemistry Laboratory Courses

Over the period of 2019-2021 continuous improvement initiatives have been launched to construct a cohesive framework around the CHEM 3000 / CHEM 3001 labs.

SKILLS-BUILDING FRAMEWORK

Tailor-made assignments and context-rich activities and discussions have been designed aiming at synergistically enhancing students' technical and professional skills. These skills-building exercises focus on scientific literacy and include sessions on how to find the right sources, how to read a journal article, how-to-write a lab report, critiquing lab reports, how to approach group work constructively, tips on giving presentations, and a set of sessions is entirely devoted to data analysis and data visualization. The figures below further detail the two main themes centering around scientific writing (Figure 1) and data visualization (Figure 2).



Tihana Mirkovic



Figure 1 Exercises that have been introduced into CHEM 3000/1 that focus on developing **scientific writing**.

While scientific writing is often addressed in some capacity at the undergraduate level, data analysis and data visualization, despite being an integral component of any research project, is often only introduced through a method-focused delivery. Addressing this gap, a series of sessions were designed to introduce the fundamental practices of data visualization with the parallel development of technical skills as students familiarized themselves with Tableau, a leading data visualization program used in industry (free for students and staff at the university). The pedagogical approach was to decouple the subject matter, advanced chemical concepts typically addressed in third-year labs, from the data visualization exercises, but rather implement relatable sample data sets with SDG themes (e.g., Global CO₂ Emission, or COVID-19 Cases in Toronto) as those are easier to grasp and allowed us to solely focus on the development of data visualization skills. The instruction centered around synchronous hand-on activities in Tableau delivered through Zoom, while student learning was catalyzed by homework assignments designed to build on in-class exercises. Both uses of data visualization, data visualization for facilitating analysis, as well as data visualization for sharing knowledge, were addressed. The data visualization deliverables of this course component, such as interactive dashboards or data stories, contributed to the development of students' personal portfolios that can be shared through Tableau Public. More on this course component can be seen in the recorded presentation given at TiF 2022 (<https://www.youtube.com/watch?v=YKJHfTrYzrU>).

CHEM 3000 Experimental Chemistry



Figure 2 Learning timeline for the data analysis and data visualization component of the course.

KNOWLEDGE-BASED RESOURCES

Newly developed laboratories and knowledge-based resources have focused on strengthening the students' basic laboratory skills and enhancing their knowledge of spectroscopic techniques, both, on the theoretical basis from a physical chemistry point of view, as well as their applicability in organic and inorganic laboratories.

One of the resources created is the 60-page - "Experimental Chemistry Lab Techniques Booklet", which has been specifically designed for CHEM 3000/1 students as it details all the lab techniques that are used across the labs in those two courses, providing students with a background on specific glassware, details on apparatuses and spectrometers, and why and how certain techniques are used, while also highlighting safety considerations. The screenshots of the typical content and layout of the booklet are shown in Figure 3. The booklet has been designed as a reference resource and students are encouraged to use it before labs in conjunction with short videos that are provided on eClass (at this point from other sources, but in the future, we plan to create our own). In 2021, when this booklet was created, we coupled it to an orientation lab (mandatory, but not graded) which was designed as a scavenger hunt where students had to perform some of the steps of key techniques utilized in CHEM 3000/1. Students had handouts which they had to fill out based on the information in the booklet and the in-lab exercises that they performed. The idea was to allow students to familiarize themselves with the lab and equipment without the added pressure of grades or performance which are typically associated with regular lab sessions.



Figure 3 Layout and content snapshots of the "Experimental Chemistry Lab Techniques Booklet".

CHEM 3000

Experimental Chemistry

ON-LINE LABS

On-line versions of the eleven of the pre-existing analysis-focused labs (9 physical chemistry and 2 inorganic chemistry) have been designed during the summer/fall of 2020 in order to ensure the safe delivery of these courses during the first year of COVID-19. The conversion process required generation of at least 15-60 data sets per lab. This time-consuming process was accomplished by building multi-step modulation and calculation schemes for each of the labs in order to generate the desired output of variable datasets. This endeavor yielded valuable test files where student generated analysis can be checked for correctness in future labs. Students received their data sets through individual folders on OneDrive. Further documents, called "Lab Book Notes", were created for on-line labs, providing a picture guide of instruments that are used for measurement, a list of all available glassware (to be considered in error analysis), pictures of solutions (to be considered for observations) and information on the configuration of data set files. On-line labs were held by TAs over Zoom and they were provided with sample questions to use in the assessment of students' understanding.

STANDARDIZATION OF GRADING

Enhancement in the standardization of grading was achieved by providing extensive support documentation to teaching assistants and restructuring the TA grading assignments. In CHEM 3000/1, prior to 2021, individual students would have the same TA for all their organic labs, and the same TA for all their physical/inorganic labs, and the same lab TA would also grade the corresponding lab reports. While the additional resources and grading rubrics helped frame expectations, inevitable subjectivity in the grading process could not be eliminated. Even doing grading exercises with TAs, where they all would be marking the same lab, did not solve the issue, as they were aware of the exercise and overcompensated for their typical standards. In 2021/2022, we modulated the TA assignments for physical and inorganic labs, which typically run in a rotational manner (e.g., 4 different labs take place on the same day), where instead of having TAs assigned to students (or groups of students) and covering all the labs, we assigned TAs to specific labs. This allowed students to be exposed to different TAs in the lab depending on which lab they were performing during a specific session. TAs appreciated this change, as they could focus on fewer labs in any given session, but also during the whole course, allowing them to optimize their instructions during the lab sessions. The grading was also standardized, so that a TA who TAed a particular lab would mark the lab reports of all students for that particular lab. By restructuring the TA lab and grading assignments, we ensured that essentially every student is marked to the same degree by each TA, thereby eliminating the subjectivity that was introduced in prior years where most of the grading for any given student would have been done by a single TA, where some could be perceived as "easy", and some as "hard" graders.

As grading is often one of the main concerns of students, I used one of our writing exercises, the "Blind-Peer-Review" assignment (see Figure 1), where students use the provided, detailed grading scheme to mark one of the labs of their peers, to also address the subjectivity/objectivity in the grading process. It was interesting to see that students were usually a bit more critical towards their peers' work than their own. I did a bit of an analysis then and compared how the student grades compared to the grades that the TAs assigned for those lab reports - the average was actually very similar. The sample size might not be large enough, but there appears to be a correlation that on average students that generally had better grades in labs gave marks closer to the grades awarded by TAs. I made a little dashboard to share with the class (data is anonymous - they can't trace who is who) - also to emphasize the usefulness of data visualization, the other topic we spend a lot of time on. This is the link:

<https://public.tableau.com/app/profile/tihana/viz/GradingAnalysis/GradingAnalysis>

CHEM 3000

Experimental Chemistry

WHAT MADE YOU UNDERTAKE THIS?

The main reasons for undertaking a number of these initiatives are either associated with having to deliver these courses during the pandemic or having to address the lack of a framework in which these courses were run, a historic decision which pre-dates my time at York.

CHEM 3000 and CHEM 3001 were originally created from labs which were associated with five third-year courses, with themes from diverse areas of chemistry and often requiring extensive background information to be provided in order for students to grasp the theoretical background. An additional complexity is that a large number of labs run on a rotational schedule (each week there could be up to 5-6 different labs running, as lab-schedules of individual students vary). The schedule rendered the tutorial not very useful (prior to 2019, a couple of different labs would be discussed in each tutorial), as often the labs covered in tutorial would not be relevant for a large fraction of the class for that week. I recognized that the tutorial could be used to explicitly focus on skills building sessions which would help students improve skills required in all their labs, or research in general, while only discussing a few specific labs during tutorial (the ones that overlap with the schedule, so that they are relevant for the whole class). The detailed notes and recordings for all labs would be provided on eClass, so that students independent of their schedule would always have access to key information for the lab that they would attend that week.

The constraints (delivery method, space/time in the lab) with having to deliver these courses during the pandemic has prompted creation of on-line labs but were also a catalyst for the design of some of the skills-building sessions. Awareness that our second-year students missed the in-person labs for their second-year organic courses in 2020/2021 prompted the creation of the orientation lab to ensure that students felt comfortable with required lab techniques, alleviating further pressure in regular labs.

WHAT HAPPENED NEXT?

The skills building sessions focusing on scientific writing (Figure 1) have been introduced over the past couple of years as I had identified the need – sometimes not within the optimal schedule. In the upcoming school year, the timeline will finally be optimized as we hope to have a full year of a one mode delivery (something I haven't had since I started coordinating this class).

The lessons learned from the data visualization portion of the course, extracted both from surveys, as well as students' shared reflections during their presentations are:

- **Technical Skills Development:** All students can follow instructions from live sessions or recordings, the calculated fields are still underutilized in independent work, ~60% can produce a good dashboard
- **Follow up use:** Students currently in the course, or alumni have noted that they have used what they have learned in their thesis research project, in their workplace, or as a hobby
- **Reflection:** >80% of students recognize data visualization as an important skill, and >50% want to learn more

CHEM 3000

Experimental Chemistry

WHAT ELSE WAS THERE TO IT? ANY ROAD BLOCKS?

The largest roadblock will remain the perception the students have about skills building sessions and if they feel like “extra” work compared to the years prior to their introduction. While I have made attempts to help integrate the exercises into existing labs (e.g., the reading exercise is on a paper that is a very good reference for one of our labs), or have switched one of the formal lab reports into a semi-formal one in order to allow the introduction of the peer-review exercise, there might be still room to optimize this integration to ensure that the workload doesn't increase in a disproportionately. A large fraction of the skills-building sessions can be mostly completed during the scheduled tutorial hour, and that might have worked best during a term when all classes were on-line. As classes switched to different modes of course delivery or switched back and forth (not just this course, but the other courses in the students' schedule) a negative impact on the live-tutorial attendance was noted. Students were still able to complete the work because of recordings or added instructions, but this is certainly not ideal. Further incentives will be explored in September in order to ensure a more stable attendance in the upcoming year.

After running the initial scavenger hunt style orientation lab, while the feedback was good overall, we might have been too ambitious in terms of how many stations we had. This year, we will scale the number of stations down (especially since the incoming students have had lab experience during the winter semester of 2022) and will focus on some of the techniques we have noticed are still not optimally understood by students throughout CHEM 3000/1 when they are rushing through their lab procedures.

HOW DID IT END?

On-line labs can be used in the future when students miss a lab and/or are unable to attend in-person. We have already used them during one of the snow days this past winter when we were scheduled for in-person labs, but the university closed. It was really convenient to have everything ready and to have TAs jump in within a couple of hours and deliver labs that typically would have to be cancelled.

The initiatives to help standardize the grading process worked really well, as very few students complained about discrepancies in grading between students in different groups. One aspect I still wish to optimize is the attendance in TA-office hours where students can get a more detailed 1-on-1 feedback. This year, we introduced the sign-up calendar on eClass for each lab report that was returned, but the pick-up on that was very low. In consultation with the writing instructor, it was suggested to keep that option in the hope that students will recognize its value.

CHEM 3000

Experimental Chemistry

BEFORE

Tutorials were used to review a few labs in the one-hour slot, often covering topics not relevant for a large portion of the class as labs have to be held on a rotational schedule and different students have different labs.

No course resource existed on the different laboratory techniques.

No on-line labs existed prior to 2020. All make-up labs (e.g. sick days, snow days) had to be made up in-person, or would have to be cut if time/space was limited.

I did not inherit any TA supplementary material for any of the 20+ labs, so I would not be able to comment on what it was like prior to 2019.

TAs looked over 4-5 lab in parallel and graded all labs from students in their lab group. Lab report grades heavily dependent on 1-2 TAs for any given student.

AFTER

Information on labs has been expanded and designed as 1-hr sessions per lab, where only some are presented during the scheduled tutorial (the ones that coincide with everyone's schedule), while others are recorded and provided to students so that all students have access to relevant lab background at the time of their lab. The freed-up time in the tutorial was used to introduce skills-building sessions (scientific writing, data analysis and data visualization). Students get to enhance their skills through active learning and hands-on exercises.

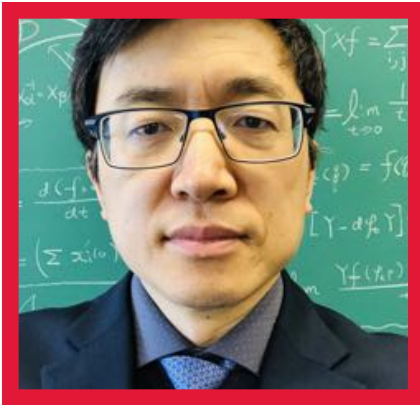
An illustrated 60-page booklet was created as a reference resource for students in CHEM 3000-1. An integrated orientation lab prompts students to get familiarized with the content at the beginning of the term and use it as a reference through out the year.

Conversion of 11 analysis-heavy labs across the two courses to on-line labs, through creation of personal data sets for each student in the class, and further support material, enabled us to delivery the lab courses during the pandemic when restrictions for in-person activities were placed. On-line labs can be used in the future when students miss a lab and/or are unable to attend in-person.

Extensive support documentation has been created for TAs for each lab to facilitate their understanding and frame grading expectations. TAs now look over 1-2 labs per session and grade the labs of all the students (all lab groups) for the particular lab that they have specialized for. Lab report grades reflect the grading of all the TAs in the course for any given student.

MATH4730

Design of Experiments



Steven Wang

START FROM THE BEGINNING. TELL US ABOUT THE TRANSFORMATION.

This course is a mandatory course for a Statistics major. It covers the theory of doing scientific research using double-blind controlled experiments. In the pandemic of Covid 19, there have been many false claims in the media and incorrect results published in scientific journals. This becomes a perfect example or test field for this course. Therefore I spend more time on the concept that is related to reality and more in particular to the pandemic. For this course, I also put in a final project component. This project is a bit unconventional since I asked students to find an article published in a decent scientific journal and find problems in their design and conclusions. I asked them to find an article published in 2020 since we know now that many of the claims are false. In this way, students can validate their critiques.

WHAT MADE YOU UNDERTAKE THIS?

Statistics is an applied science. But the teaching of Statistics has not always been that way. This might be a disconnect between the theory and the practice in our traditional thinking. The unfortunate pandemic of Covid-19, however, provided sufficient material and also motivations for students to take a closer look at the theory and its relevant to the reality.

WHAT HAPPENED NEXT?

I will not be teaching this course. But I will carry the same method to all of the other courses that I will be teaching in the future.

WHAT ELSE WAS THERE TO IT? ANY ROAD BLOCKS?

So far so good.

HOW DID IT END?

I think that students might not be able to forget this exercise and will be able to master the principle of design of experiments.

MATH4730

Design of Experiments

BEFORE

- Assessments were tests
- Possible disconnect between theory and practices

AFTER

- Final project where students needed to find an article published in a scientific journal and find problems in their design and conclusions
- Used COVID-19 statistics to field test statistical theories in the course

STC/NATS SCIENCE & TECHNOLOGY / NATURAL SCIENCES

START FROM THE BEGINNING. TELL US ABOUT THE TRANSFORMATION.

The most significant transformation to my teaching arising from the pandemic is the addition of real-time, virtual observing sessions in my courses. Owing to out-of-province travel restrictions, I've spent the last two summers exploring Ontario's fabulous plethora of provincial parks and campgrounds, where skies are dark and the Milky Way clearly dominates the night sky. While on sabbatical in 2021-22, I attended workshops in which astronomy profs incorporated realtime observing in their online courses as a "virtual" field trip. I have since acquired the equipment and setup necessary to run live, mobile online observing sessions, enabling me to bring the dark skies and breathtaking Ontario landscapes to the hundreds of students in my courses. I plan to pilot this in my online History of Astronomy course in Summer 2023. Students will observe the cycles of the sky in real-time rather than via PowerPoint slides. They will see live views of the planets and other solar system objects and be able to ask questions about what they're seeing. Students will also learn how to take high-quality photos of the night sky with their phones, adding an experiential component to the course as they reflect on the challenges of light pollution and the increasing satellite traffic and space debris in near-Earth orbit. Most importantly, students will gain an appreciation for the importance of preserving our parks and dark skies.



Robin Metcalfe

WHAT HAPPENED NEXT?

In addition to the above, the transition to online learning led to some delivery enhancements which I plan to incorporate into my future online, hybrid and in-person courses. For example:

- Daily online office hours in lieu of email: When I became the NATS UPD in 2019, the amount of emails I was receiving from students, TAs and faculty became so overwhelming that I had to prohibit emails from my own students. Instead, I went "old school", telling students that communication outside of class time was only permissible during my twice-weekly office hours or before/after class. Not surprisingly for a commuter school, my office hours were not well attended. When the University closed during the pandemic, I switched my office hours to Zoom sessions and was able to hold them daily. Students dropped by nearly every day, some with questions and some just to chat. I was able to resolve students' questions and administrative issues far more quickly and effectively than via back-and-forth emails, which can often be de-humanizing in online courses where there's very little face-to-face contact. As evidence of this, I found that at the end of each term, I knew more students by face and name than I had in my in-person classes, owing to the many face-to-face chats I'd had with individual students during my office hours. I will definitely be continuing this strategy in all of my courses going forward.
- Assessments which promote deeper learning: Prior to the pandemic, my tests and exams were primarily multiple-choice, content-heavy assessments with few opportunities for critical thinking or reflection. The transition to online, cumulative assessments necessitated a switch to short- and long-answer questions as it is nearly impossible to maintain academic honesty with the multiple-choice format. The transition therefore created opportunities to design test questions which go beyond content memorization and require students to demonstrate original and critical thinking by making lateral connections between the course content, real-life scenarios and current events. As a specific example, in one of my astronomy exams, students are required to play the role of a planetarium host and take a lay audience through a tour of the night sky on a given date. Students must draw together relevant course material from different lessons and present it in engaging and digestible way. By preparing for such assessments, students acquire deeper learning and retention as well as an appreciation for the relevance of the course material beyond the course itself.

STC/NIATS SCIENCE & TECHNOLOGY / NATURAL SCIENCES

- Randomized group work: All of my courses contain opportunities for students to complete in-class activities in groups. In a large, in-person class, students tend to work only with the friends sitting around them. The transition to Zoom breakout sessions made it possible to quickly place students into randomized groups. At the start of each 3-hour session, students conducted a quick ice-breaker to get to know each other, then completed an assessment together, switching back and forth between the main Zoom room and their group as we took up sections of the assessment together, dealt with questions, then returned to the group rooms to complete the next part of the activity. Anecdotally, I learned that many students appreciated the opportunity to make new connections with classmates. Going forward, I will continue this strategy in my online and hybrid classes and will evaluate its effectiveness via student surveys and performance statistics. I am also investigating methods for efficiently organizing students into random groups in large in-person classes.

BEFORE

- No method for observing sessions with large class
- Email communication with students
- Traditional tests and exams with multiple-choice
- Students work in groups with people sitting near them

AFTER

- Mobile observing sessions to bring the dark skies and breathtaking Ontario landscapes to the hundred of students in my courses
- Daily online office hours
- Assessments that promote deeper learning that go beyond content memorization and require students to demonstrate original and critical thought
- Use of randomized group work to encourage making new connections with their classmates

CHEM1000

Introductory Chemistry

START FROM THE BEGINNING. TELL US ABOUT THE TRANSFORMATION.

Introductory chemistry courses were being delivered in a traditional only-summative assessment format (one or two midterms and a final exam). Labs were also administered in a cook-book approach. Active learning components like peer discussions, think-pair-share, in-class demonstrations, feedback enabled online homework and clicker-based formative assessments were quite fitting for our large multi-section classrooms (~1400 general chemistry and ~750 organic chemistry). Administering and marking labs, midterm and exams has also proved to be an issue, given the large number of sections.



Hovig Kouyoumdjian

WHAT MADE YOU UNDERTAKE THIS?

Teaching a large class could be quite challenging for both the instructor and the students, and hence keeping students engaged and focused is crucial. Clickers made it easier for us to assess students learning in the class and also kept students engaged, especially when it couples with the think-pair-share leaning strategy. Labs too lacked engaging components. Marking was done manually by many TAs and faculty members which delayed the process for days.

WHAT HAPPENED NEXT?

We incorporated many new active learning strategies and technologies to enhance students' experience in these courses.

Tablet-assisted wireless teaching (Microsoft Surface) enabled us to scaffold ideas and concepts by annotating half-filled PowerPoint slides. We also used the camera functionality to show dihedral rotations (Newman projections) and ring-flipping of chemical compounds.

Clickers were incorporated in the course for the first time in the department.

Feedback-enabled online homework and quizzes were introduced.

Adobe Connect software was used for online tutorials, which also enabled us (back then) to transition to online teaching smoothly during the 2018 strike. This was replaced by zoom during the pandemic.

Adoption of Crowdmark for lab, assignment, and exam marking.

Introduction of VernierLabQuest 2 standalone interface which was used to collect sensor data with its built-in graphing and analysis application. This was introduced for CHEM1000 laboratories.

WHAT ELSE WAS THERE TO IT? ANY ROAD BLOCKS?

Technology can be used for enhancing good teaching practices, but it might also constitute a challenge. Many "standard operating procedures" and tutorials were created to assist students setting up accounts, view the created educational content, and to train on the LabQuest 2 interface, yet we still noticed issues with technology and also with chemistry misconceptions (on tests and exams).

HOW DID IT END?

Although the feedback was positive in general, but we still needed to develop specific assessments to gauge students' understanding of particular learning objectives. This iterative process made it easier to fine-tune the learning experience over the past academic years. It is also worth mentioning that adhering to the Zone of Proximal Development (ZPD) was always at the centre of what we created for these courses.

Introductory Chemistry

BEFORE

- Traditional presentations, chalk talk
- No formative assessments in class (Clickers)
- No feedback-enabled online homework and quizzes
- Traditional labs
- Traditional exam administration and marking

AFTER

- Tablet-assisted power point presentations (annotations)
Microsoft Surface features that were used: WiDi, camera, built in software, etc.
Use of Adobe Connect for online tutorial (and lectures during the strike)
- Introduction of formative assessments (Clickers)
- Introduction of feedback-enabled online homework and quizzes
- Introduction of technology in labs (LabQuest 2)
- Introduction of Crowdmark

STS3780 Biomedicine in Society

START FROM THE BEGINNING. TELL US ABOUT THE TRANSFORMATION.

About 10 years ago I taught this as a course about professionalization and specialization; kind of ‘sociology of biomedicine.’ (topics included: why do dentists and doctors go to different schools? Why do nurses make less money and have less prestige than doctors, but often have more experience than them? We think “empowered” patients are great...but what happens when they’re wrong? What larger points can we learn about scientific expertise?)

Following my new interests in fraud, I decided to focus on cheating in biomedicine and the academy, and structured the course starting with minor infractions (cheating on exams, plagiarism) to middling infractions (research misconduct, the replication crisis) and ending with major ones (fake doctors; Theranos).

It is extremely important to note that the purpose of the class was not to make students cynical about the sciences and biomedicine (especially these days) but rather as a back-handed way of learning about ethics in science by learning what not to do. The model for this course was a class taught at CalTech by physicist David Goodstein, who describes it in his 2010 *On Fact and Fraud* (PUP). **The intention is to rediscover what is special about the sciences (and research in general) and thereby recover the underlying idealism of scientists and researchers.** This can be done by openly looking at problems, especially structural ones (e.g. the numerous incentives to publish quickly, to monetize one’s work if possible, or to unthinkingly use productivity metrics like the H-index).

WHAT MADE YOU UNDERTAKE THIS?

By 2022 the readings I’d used had become a little dated and my interests had moved on; moreover as a seminar course (student n <40) I knew that a course structured on discussions would be challenging, especially if we went back into lockdown.

My own research has moved from a history of testing and credentials into an interest in when such credentials don’t work or don’t actually do what they’re supposed to (e.g. fake doctors, bought degrees, cheating on tests).

I am convinced that most research on this, such as Sarah Eaton’s, misses the bigger picture by being too focused on individuals (e.g. a focus on ‘academic integrity’) while ignoring larger structural incentives (e.g. in business or administration, when faced with a problem, one outsources and calls in an expert...why should this be any different with a student who just has to pass that required class in, say, organic chemistry or accounting?).

My time on CEAS has been eye-opening, and I don’t think we have even scratched the surface of academic misconduct – we only catch the most obvious violators.

Finally I also think we can tie problems of cheating with crises in research and replication (see for instance Nicolas Chevassus-au-Louis, *Fraud in the Lab*, HUP 2019, or former *Lancet* editor Richard Horton’s shocking 2015 claim that “much of the [biomedical] scientific literature, perhaps half, may simply be untrue.” see “What is medicine’s 5 sigma?” *Lancet* 385, p. 1380, 11 April.) Again, what matters are not simply individual ‘bad apples’ but larger structural incentives.

So why not talk with students who are at the front line of this?



James Elwick

STS3780 Biomedicine in Society

WHAT HAPPENED NEXT?

In class setup:

Use of the online collaborative space MURAL, which allowed multiple users at once to work together and then generate notes as a PDF.

To encourage discussion despite the problem of 'blank Zoom screens' we used the 'conversation café', a highly structured discussion format (talking circles with a 'talking object'). I set the topic for a given class: e.g. 'Come up with a fraudulent biomedical company like Theranos, brainstorming features that enhance its ability to do harm or make misrepresentations.'

Use of 'skeumorph' design principle (online space looks exactly like in-person space so that everyone follows the same setup regardless of being online or in person, so for instance when in the classroom they sit in circles; online, they sit in virtual 'circles.') This repetition leads to familiarity. This worked well with hybrid format, when some participated remotely (COVID prohibited them from coming to YU) and some were in person.

Assignments:

'Client proposal' to come up with a system to reduce cheating or misconduct, or learn more about it; e.g. go out and comparison shop at essay mills.

Idea here was to make this for a specific audience and try a 'real-world' piece of communication rather than the standard essay; possibly something 'actionable.'

'Career arc' of a researcher featured in www.retractionwatch.org or one's own choice (e.g. UGuelph scientist Stephen Newmaster's problems, <https://www.science.org/content/article/this-scientist-accused-supplement-industry-of-fraud-now-his-own-work-is-under-fire>; the USask health researcher Carrie Bourassa who falsely claimed to be Indigenous)

Idea here was to try to understand why the 'bad scientist' did the bad things they did by looking at their life and context and incentives, then propose solutions, corrections.

Exams, pop quizzes, heavy participation scores.

WHAT ELSE WAS THERE TO IT? ANY ROAD BLOCKS?

Assignments:

The client proposals did result in actionable and concrete things (see example of comparison-shopping in essay mills; another proposed an app that would harvest professional societies' membership lists to show if that person treating you is really a doctor).

But the specifications need reworking and clarification (were the students proposing new ways to cheat like 'white hat' hackers do, to discover cheating, or to thwart it?)

- Nb I always ensured that students drew positive things and lessons for how to improve science/research/academic integrity...if not done carefully I worry about a danger of instilling cynicism and even nihilism in the students. So whenever it did crop up in discussion, I reframed towards how to make things better.

Participation:

I discovered (obvious in retrospect) that if one sets out high participation requirements, then one must provide options to remotely participate, especially if one is not allowed on campus due to COVID.

This is complicated by the fact that the easier remote participation is made for the students, the less likely that one's students will come in and participate in person. Why make the trek if one can do things online?

Biomedicine in Society

HOW DID IT END?

Students enjoyed it and it certainly led to interesting discussions, although this made me more of an 'in person' purist when it comes to discussions. Zoom/ remote discussions can never be as 'generative' and interesting as in-person ones

Many topics were too demanding for the 3rd year students; it's more suited as a graduate class, particularly when we get to research misconduct.

I marked the students too leniently, since it was a new and highly experimental class.

STS3780

Introductory Chemistry

BEFORE

- Mostly research-based, write the standard essays, reading.
- In-person discussions (as little lecturing as possible, always going back to readings)
- Use of conversation café format online (lockdowns) without MURAL meant unstructured, unfocused conversations

AFTER

- Actionable, concrete client proposals; one could call some aspects 'experiential education'
- More lecturing (because lockdowns meant online work less conducive to discussions), unfortunately
- Use of MURAL and requirement of 'deliverables' meant some more structure, useful discussions. But not as good as in person.