## Finding the Silver Lining During a Global Pandemic: Opportunities for Curriculum Innovation in Microbiology Education

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Finding the Silver Lining During a Global Pandemic: Opportunities for Curriculum Innovation in Microbiology Education

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The global COVID-19 pandemic has changed the face of higher education in Canada. Canadian universities were among the first to announce that the fall semester will be delivered in an entirely (or partially) online format (University Affairs, 2020). This means many microbiology educators will not be able to teach courses, including labs “as usual” in the Fall 2020 term and possibly the Winter 2021 term, depending on the outcome of the pandemic and a possible second wave. The situation we find ourselves in brings with it an urgent challenge: to ensure that microbiology students remain engaged and able to acquire essential skills in an online format, or a condensed lab format that can be offered to students when physical distancing restrictions change to allow face-to-face instruction (Noel et al. 2020). We believe that while we certainly face unprecedented challenges in course delivery, the current situation provides educators with an opportunity for innovation in our curricula and to incorporate novel approaches in microbiology education in Canada.

Experiential learning has long been the hallmark of undergraduate laboratories. However, historically many undergraduate labs have followed a highly structured format, leading students through illustrative examples, rather than testing critically developed hypotheses. In the current educational environment, where delivery of such labs may not be possible, innovations in experiential learning are required. Additionally, experiential learning need not be restricted to lab-based, hands-on skill type courses. Experiential learning can be delivered in many formats, both in the lab and classroom, including an on-line format. Reframing the current crisis into an opportunity for pedagogical innovation and creation of new learning and assessment strategies will result in a ‘COVID-19 legacy’ of instructional tools that will be beneficial for years to come.
To get educators started on this path, here are five examples of curriculum innovation that can be incorporated into microbiology education:

1. **Data analysis and critical thinking, including ethical discussions at all levels**

   For many undergraduate courses in microbiology, the process of analyzing data, interpreting and drawing conclusions based on those data to decide on next steps, is reserved for upper year students. We encourage educators to replace cookbook/survey labs in 1st and 2nd year with labs that focus on having students think critically or incorporate themed active learning activities in the classroom. This could be as simple as having students interpret and describe the main points of a graph from peer-reviewed publications. This approach not only allows the students to understand the biological phenomena, but also to extract and interpret useful information from scientific articles. Such an assignment will also help develop written or oral communication skills early. Educators can also use the Consider, Read, Elucidate the hypothesis, Analyze and interpret the data, and Think of the next Experiment (C.R.E.A.T.E) method (Hoskins et al. 2011, [https://teachcreate.org/](https://teachcreate.org/)) to encourage students to interact and engage with primary literature. Recent work by Krufka et al. (2020) can aid educators with minimal C.R.E.A.T.E training in incorporating this method into their teaching. Alternatively, educators can incorporate case studies ([https://sciencecases.lib.buffalo.edu/](https://sciencecases.lib.buffalo.edu/)) as a way to teach critical thinking skills. For example, 1st year microbiology students can learn about emerging infectious diseases and global pandemics ([https://sciencecases.lib.buffalo.edu/collection/detail.html?case_id=697&id=697](https://sciencecases.lib.buffalo.edu/collection/detail.html?case_id=697&id=697)).
can also provide students with practical experience in critical thinking by introducing
discussions on ethics of research into our virtual classrooms or laboratories. Smith (2014)
explains why ethical discussions are essential in a science classroom and provides tips of
how one can introduce and structure such discussions.

2. **A focus on experimental design in the lab**

In most cases, due to time constrains during the semester, undergraduate labs fail to
provide the necessary instruction on important aspects of experimental sciences such as
replication, sample size, reproducibility, and additional critical thinking required when
designing experiment to answer biological questions. Examples of training modules
(complete with discussion notes and additional educator resources) can be found here
([https://www.nigms.nih.gov/training/pages/clearinghouse-for-training-modules-to-

3. **Science communication elements**

Microorganisms affect almost every aspect of our lives, yet there is general public fear
surrounding them. Timmis et al. (2019) discuss why there is an urgent need for
microbiology literacy in society. As educators we can participate in this initiative by
putting emphasis on training our students to communicate research in microbiology to a
general audience. For example, students could create a podcast or a blog reviewing a
recent journal article. If peer review (by fellow students) is incorporated to this process, it
could lighten the grading burden. Another way of getting students involved in science
communication and improving microbiology literacy, is to create
4. **A focus on bioinformatics competencies**

It is now common for microbiology research to use “omic” technologies to answer scientific questions. This means undergraduate microbiology students not only need a thorough understanding of these technologies but also basic bioinformatics skills prior to degree completion. Skills such as learning Unix command line, R, and Python are valuable to microbiology students independent of their chosen career. Learning bioinformatics skills can be incorporated into microbiology courses, at any level. Educators may use the bioinformatics mastery rubric developed by Tractenberg et al. (2019) to promote bioinformatics practice in the classroom and lab settings to achieve the associated competencies in undergraduate education. Educators can also choose to include bioinformatic skills in the learning environment using a software carpentry format (https://software-carpentry.org/).

5. **Incorporating equity, diversity, and inclusion into the microbiology curriculum**

Another important topic that requires a permanent place in our curricula (regardless of the current situation we find ourselves in) is an honest and ongoing discussion about equity, diversity, and inclusion (EDI) with our students. Systemic racism and sexism have contributed to various forms of bias in scientific research. Hunter et al. (2010) describe how we can incorporate and support EDI initiatives in our classrooms and
laboratories. In addition to undertaking EDI initiatives, educators should consider dedicating at least one class or lab session to facilitate a discussion on systemic racism and sexism in STEM fields. For more information on inclusive science please refer to Volume 21 Issue 1 of the Journal of Microbiology and Biology Education (https://www.asmscience.org/content/journal/jmbe/21/1).

As educators we have a responsibility to not only provide our students with an inclusive environment, but to also teach our students about the importance of diversity in microbiology research. For example, what are the consequences of only including white males in a microbiome study? Or how does only including male mice in a study bias the results? A recently published meta study by Woitowich et al. (2020) can be used to introduce historical biases and what is currently being done to prevent this in the research community.

The current challenges we are facing as educators have exposed opportunities for pedagogical innovation. Postsecondary enrollments in the life science and health related fields in which microbiology serves an important role in the curriculum, are steadily increasing (Statistics Canada, Table: 37-10-0011-01). Equipping these students with the theoretical knowledge and practical skills, they seek from a microbiology class will require us as educators to get creative and find new approaches for content delivery. Although the resource list we have provided is not exhaustive, we hope that it lets you see that there is light at the end of the tunnel. The necessary shift to in silico delivery may facilitate the development of computational biology and big data management skills, which along with classical laboratory competencies, are going to be key to addressing future demands.
Additional resources

This editorial was written as a collective effort of the Canadian Society of Microbiologists (CSM) Committee on Microbiology Undergraduate Education. The authors are happy to provide detailed commentary or additional thoughts on the ideas discussed here.

Resource links:

- [https://teachcreate.org/](https://teachcreate.org/)
- [https://sciencecases.lib.buffalo.edu/](https://sciencecases.lib.buffalo.edu/)
- [https://www.calacademy.org/educators/lesson-plans/choose-your-own-citizen-science-project](https://www.calacademy.org/educators/lesson-plans/choose-your-own-citizen-science-project)
- [https://tinyearth.wisc.edu/](https://tinyearth.wisc.edu/)
- [https://software-carpentry.org/](https://software-carpentry.org/)
- [https://www.asmscience.org/content/journal/jmbe/21/1](https://www.asmscience.org/content/journal/jmbe/21/1)
161 References:


174 Noel, T et al. 2020


178 Statistics Canada. Table 37-10-0011-01 Postsecondary enrolments, by field of study, registration status, program type, credential type and gender. doi: https://doi.org/10.25318/3710001101-eng

