

# INQUIRY-BASED EDUCATION AT CANADA'S NATIONAL SYNCHROTRON FACILITY

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Recent science curriculum reform emphasizes student learning through inquiry practises that mirror the processes and activities of professional scientists [1]. Evidence suggests a decline in innovative student-centred practices as students advance in their education due to heavy content-load, rigidly structured curricula, and a lack of appropriate teacher training [2]. There is also often confusion between the pursuit of inquiry for research purposes (to produce novel information) and for educational goals (provide a learning experience) [3]. Education programming at CLS is based on authentic inquiry experiences that finds a balanced interplay between educational and research goals for high school and undergraduate students. The Canadian Light Source (CLS) is Canada's national synchrotron radiation facility. It has been utilized by several thousand researchers since the beginning of operations in 2005. More than 850 of those researchers are high school students from eight provinces and two territories.

## BACKGROUND

There are three cornerstones for all of the education programs at CLS. First, the focus of the experience is on learning *processes* of science, including conventional skills like literature searches, data analysis (Fig. 1) and formulating a hypothesis, as well as teamwork, time management, and communication skills.

Second, the inquiry must be open-ended, meaning that the question or hypothesis must be something for which the answer is not already known. These are experiments, *not* demonstrations. Third, the experience is collaboratively supported by experts but *student* driven. Students work with science mentors, whose role is to provide advice throughout the process, but *decisions* are made by the students. Mentors are drawn from CLS scientific staff and other interested scientists, including graduate students, and the process is facilitated by the Education Team at CLS. Inquiry-based teaching practices are required in most Canadian provincial

## SUMMARY

This paper describes inquiry-based education programs at Canada's national synchrotron facility where students learn the process of science in a student-driven environment.

school curricula and are encouraged at post-secondary institutes. Collaboration between education and research is key.

## HIGH SCHOOL PROGRAMS

There are two programs for high school students. Students on the Beamlines (SotB) was initially a single experiment that grew into an award winning program over 10 years [4]. Students from across Canada submit proposals hoping to be granted a single shift of beamtime where they perform an experiment using CLS beamlines, after spending several months working with mentors to develop an appropriate project such as investigating the effects of acid rain on spider silk or tracking chemical changes over time in tree rings. Most groups are extra-curricular clubs comprised of as few as three or as many as 19 students ranging in age from 14 to 18. The projects culminate in student presentations to CLS staff (Fig. 2), to their home communities, a scientific poster and sometimes a paper. This hands-on (Fig. 3) authentic experience has been transformational for the 650 students and teachers [1] that have participated. The result is highly engaged high school students, "We will be allowed to conduct research, not simply have a trial run, but contribute to the scientific community itself, a prospect that is endlessly exciting." [5]

A second school program, still under development, was designed specifically for full classes to participate in an investigation tied directly to learning outcomes in the curriculum, as part of NSERC's Science Odyssey program. In this program, called Light Source Student Experience (LSSE).



Fig. 1 Quebec students cluster to analyse their x-ray spectra data as they prepare to make their first presentation of their findings.



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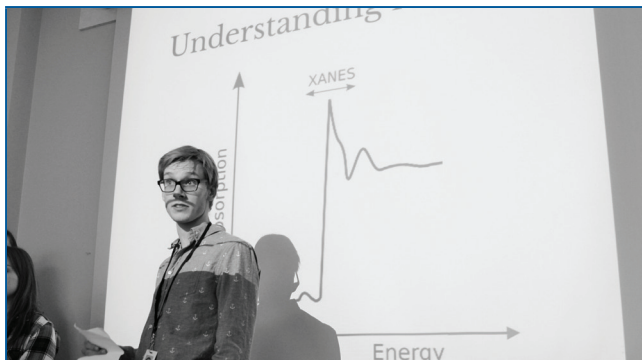


Fig. 2 A Saskatchewan student explains how to read x-ray spectra as part of their presentation to CLS staff.



Fig. 3 A Saskatchewan High School student taking her turn to place a sample in the chamber at the beamline.

Students propose a question relating to soil chemistry and collect samples from their community. Each class returns to their classroom with their data to analyze and with access to data of other classes for comparison. In its inaugural year 199 students participated.

## UNDERGRADUATE PROGRAMS

CLS has several pilot projects underway to explore how the three cornerstones of education programming (a focus on process, open-ended inquiry, and collaborative support from experts) fit with undergraduate teaching. At the University of Saskatchewan, on

whose campus CLS is located, a group of first-year students taking an Environmental Studies course opted-in for a special project following the SotB model as a replacement for the tutorial section related to the class. This model is also being tested at a distance through a collaboration with, McGill University MacDonald Campus, where their internship program enabled a small group of students to conduct CLS research.

To test a different approach, specialized interdisciplinary courses are offered to third and fourth year students in Chemistry, Education, and Humanities. Students must rely on their own specialized knowledge in the pursuit of a collaborative multidisciplinary experiment, aligned specifically with each department's program as an integral part of the syllabus. These courses are collaboratively taught by department faculty and CLS staff.

## TEACHER TRAINING & RESOURCES

In an effort to support teachers who wish to connect current scientific research with curriculum, CLS offers a professional development workshop annually. This workshop also serves as training for the SotB program. Since 2005 more than 180 teachers have attended workshops. If one assumes that each of those teachers taught 75 students each year, that results in nearly 14,000 students connected with scientific research at CLS. In addition, there are a number of teaching resources and lesson ideas available on our website, such as problem-based learning cases involving crystallography and drug design or an information package explaining several different methods of medical imaging and how they are used in diagnostics.

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