

E-Content

A New Approach to Science Education for the 21st Century

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Modern society faces increasingly complex problems. To address these problems, higher education needs to produce a new type of scientist—one who understands a broad range of disciplinary approaches, is able to ask creative questions, and is trained to answer those questions with a wide range of tools. This 21st-century scientist must have a skill set that allows him or her to probe and explore problems, to find and critically evaluate information, to work productively as a member of a team, and to effectively communicate research findings to others. The Honours B.Sc. Integrated Science (iSci) Program at McMaster University, the first of its kind in Canada, has been designed to educate such scientists. This unique, interdisciplinary, research-based science program is targeted toward highly motivated, high-achieving students and has an enrollment limit of sixty students per year. The first cohort of iSci students arrived at McMaster in September 2009.

The iSci program is structured such that in the first year, students take a single course in which they learn and integrate the content and skills in the areas of life sciences, chemistry, physics, mathematics, psychology, and earth science. This course counts for eight of the ten courses that students take in the first year, leaving two courses to be selected by students as electives. In the second year, students take the equivalent of six courses of integrated science and four elective courses, and in the third and fourth years, the elective component increases to six courses per year. This structure allows students to fully develop an interdisciplinary approach to science over the four years of study but also allows them to focus their electives in a particular field of specialization (e.g., physics, chemistry) if they so wish.

The iSci program was designed and developed over a period of four years by research- and teaching-track faculty representing each of the scientific disciplines, as well as by librarians from the University Libraries. The program is administered by a director and is taught by an interdisciplinary team of twelve instructors (the iTeach team) with expertise in the areas of life sciences, mathematics, physics, astronomy,

chemistry, biochemistry, earth sciences, neuroscience, and information science. The two teaching-track faculty on the iTeach team have a particular interest in pedagogical research and in the development, application, and assessment of appropriate pedagogical methodologies in the iSci program. The iTeach team has also established an online forum—iSPHERE (http://tech.groups.yahoo.com/group/isphere_group/)—for the exchange and communication of ideas, resources, and experiences for those involved in the development and implementation of interdisciplinary science programs in higher education. iSPHERE is intended to facilitate the growth of an international community of educators involved in interdisciplinary science.

Teaching and Learning

The integration of discipline content and skills occurs through a modular, theme-based approach to the curriculum. In the first year, students are transitioned into the self-directed, inquiry mode of learning that characterizes the iSci program through a six-week “foundations” module. In this module, they learn core content and skills relevant to each of the science disciplines through examination of pertinent issues and problems. Students are taught by interdisciplinary teams of instructors in laboratory and field settings, as well as in “integrated concept seminars” (iConS), an instructional situation that blends lecture, tutorial, and active learning. The focus at all times is on engagement of the students in the learning process using hands-on experience wherever possible and employing appropriate technology (e.g., clickers, podcasts, interactive whiteboards). In the first six weeks of the program, students are also introduced to the fundamental processes and skills needed for effective inquiry-based learning conducted in teams.

In week seven, the students embark on their first three-week research project (*Mission to Mars*), in which they begin to take responsibility for their own learning but are closely directed by instructors. This is followed by a second three-week research project (*Drugs, Diffusion, and Biodistribution*). By the beginning of the second term, the students have gained some experience in determining their own research and learning protocols and can take more responsibility for the direction of their research and learning in two six-week projects (*Sustainable Energy* and *Finding a Cure for Cancer*). In the second year, iSci students further develop their research skills through the investigation of issues related to neuroscience, thermodynamics, quantum mechanics, cell biology, ecology, and biochemistry. By the third and fourth years, research projects will be conducted by teams of students working in faculty research laboratories. The iSci approach focuses on supervised inquiry-based learning that is project-oriented rather than course-oriented and allows students to develop an understanding of the connections between various scientific disciplines as well as the relevance of science to modern society.

21st-Century Fluencies

The iSci program is committed to ensuring that students are not simply read-and-write literate but also have new fluencies appropriate for the 21st century, a goal shared by the University Libraries. These fluencies represent the modern skill set that students will need in order to thrive and succeed as scientists and citizens in and beyond academia. These skills include using and applying new media and communication tools (video, audio, mashups, mobile computing); harnessing the power of visualizations (images, design, aesthetics); locating and critically using information; and understanding how science is communicated and the role of science in society.¹

To impart these skills, the iSci curriculum includes, in the first and second years, a weekly class dedicated to science literacy. This component of the course covers issues of reading, writing and communicating science, as well as techniques in information use and acquisition. Example topics covered thus far are “introduction to library resources,” “precis writing,” “peer editing,” “how to read a scientific paper,” and “dos and don'ts of oral presentations.” The deliverables for each of the four research projects conducted in the students’ first-year course require using different communication styles targeted to different audiences. For example, the second project (*Drugs, Diffusion, and Biodistribution*) involves the creation of an informational poster designed for a general audience, whereas a later project (*Sustainable Energy*) requires drafting a proposal targeted at policy-makers. Other coursework in the program involves making wiki contributions, creating podcasts and video recordings, and using other modern media technologies. The students interact on a thriving Facebook page, where they share web links and ask each other questions. Introducing science literacy in the first year is uncommon; most other students will not receive similar development until much later, often only in graduate studies.

The program also has an embedded Science Fluencies Librarian. The librarian is invited to contribute to curriculum, visit classes, teach, and collaborate. There is a great opportunity for just-in-time information literacy sessions, based on the observed needs of the students. The involvement of a dedicated librarian in the development and instruction of the iSci program, particularly at the first-year level, allows students to appreciate the importance of library and information science and its links to overall, effective scientific communication.

The Learning Space

The library partnership with iSci extends into the learning spaces as well. The Faculty of Science and the University Libraries worked together to provide iSci with a modern home in the H. G. Thode Science and Engineering Library. Over the spring and summer of 2009, intense planning and work was done to renovate the third floor of the Thode Library and transform it into three distinct spaces. The north wing of the floor has become the high-tech Thode Interactive Knowledge Classroom—or simply, the “ThInK Space.” To accommodate group-learning activities, this room places students in groups of four around one of the twelve workstations in the room. Each of the students’ screens at these workstations can be triggered to display on all of the other screens in the room, to encourage the sharing of findings and ideas. At the center of the class is an

interactive whiteboard, to facilitate seamless interaction between the instructor and the instructional software.

At the other end of the third floor is the iStudy space, which is a dedicated study area for iSci students. Ample whiteboards and large tables provide room for collegial sharing of information. Other features include comfortable seating, individual study carrels, WiFi, power for laptops, and a small library of resources. This area has become a hub for the students, who use it to plan, study, practice, and interact.

Finally, in the center core of this floor are the office spaces, which include space for the director of the program, two teaching faculty, an administrator, and a librarian, along with a work/meeting room for the iSci faculty. The close collaboration of faculty, administrators, the lab coordinator, and the librarian is facilitated by the shared working space.

Looking to the Future

McMaster University has a culture of innovation in education. The iSci program provides a new and innovative model for science education. The interdisciplinary, inquiry-based approach will allow students to develop an understanding of how new knowledge and skills are created across scientific disciplines and how this knowledge and these skills will shape their attitudes, flexibility, and skills in ways that will augment their performance in future careers. The seamless inclusion of 21st-century fluencies in their learning environment will provide the broad range of tools necessary to tackle complex multidimensional problems and to effectively communicate with a range of audiences. The iSci program is viewed as an incubator for new ideas, teaching and learning strategies, technologies, and partnerships that may be more widely applied in the McMaster and global university environments.

Note

1. George Lorenzo and Charles Dziuban, "Ensuring the Net Generation Is Net Savvy," *EDUCAUSE Learning Initiative (ELI) Paper 2*, September 2006, <<http://net.educause.edu/ir/library/pdf/ELI3006.pdf>>.