Innovating, integrating, and influencing: A science program for the 21st century

Sarah L. Symons, Chad T. Harvey, and Carolyn H. Eyles, School of Interdisciplinary Science, McMaster University.

Contacts: symonss@mcmaster.ca, harvech@mcmaster.ca, and eylesc@mcmaster.ca

ABSTRACT

McMaster University's Honours Integrated Science Program (iSci) was the first 4-year integrated science degree program in Canada. It is research-based, both in its pedagogical design as well as in how the students learn in program. This chapter will describe the development, delivery, refinement, and achievements of iSci since before the first cohort were accepted (2009) up to the present. We approach this through the lens of influence—the influences on the program and the program's influence on external programs and approaches, highlighting the program as a pedagogically innovative and ground-breaking undergraduate science degree. We will concentrate upon four main areas that are indicative of iSci's innovative structure and approach: (a) the way we achieve and embody integration and interdisciplinarity with our custom pedagogical model; (b) our focus on communication and collaboration—between students and across cohorts, between instructors through active co-teaching, as well as openly among students and instructors; (c) the role and results of science literacy (in its broadest definition) being at the core of the program; and (d) the expected and emergent results of our decade-long, longitudinal pedagogical research study. The development of the iSci Program is iterative and on-going; it integrates influences and innovations, both internal and external, responding to the changing interests and needs of students, instructors, and the global landscape of higher education.

KEYWORDS

interdisciplinarity, collaboration, research-based education, science education, science literacy

The Honours Integrated Science (iSci) program at McMaster University accepted its first cohort of students in September 2009 as a new, pedagogically innovative, and exciting undergraduate program with a societally relevant approach to the learning of modern science. This chapter describes the development, delivery, refinement, and achievements of the iSci Program from its inception prior to 2009 up to the present; particular attention is given to the identification of factors that influence the program and how the program has influenced pedagogy, program structure, and the need for integrated communication across all levels of program structure, as perceived by three members of the design and instruction team. The distinctive approach the iSci Program applies to the learning of science includes mechanisms to integrate (a) an innovative course structure and custom pedagogical model, (b) scientific disciplinary content, (c) a focus on communication and collaboration between instructors, staff, and student cohorts at all levels, and (d) a longitudinal pedagogical research study in which iSci students and alumni are involved. The development of the iSci program is iterative, integrating influences and innovations, both internal and external, and responding to the changing global landscape of higher education (for example, through collaboration with an equivalent program in the UK).

INNOVATION OF A NOVEL PROGRAM STRUCTURE

iSci was the first 4-year integrated science degree program in Canada. Today, there are a few, but when we started there were only 1-year foundation programs in Canada and 3-year programs in other countries like the UK. Our new program, into which students would enter directly and stay for 4 years, immediately gave us a huge advantage in being able to plan their progression and guarantee what they were learning from level to level.

The idea for a fully integrated, innovative, flagship program focussed on research-based learning of interdisciplinary science came from the then Dean of Science, Dr. John Capone. His vision was for a program which bridged science disciplines, highlighting the innovation in teaching and research across the faculty and acting as a pedagogical hub for the exchange and testing of educational ideas. By 2007, a committee under the leadership of Carolyn Eyles had been formed and produced a specification or “visioning” document to which we, as the core instructors of the program, still refer (Eyles & Racine, 2007). The original program design committee involved representatives from each department in the Faculty of Science, a student, the assistant dean, plus the university librarian. The first cohort entered the program in September 2009.

The remit for the program was, in brief, a 4-year undergraduate honours degree called “Integrated Science” and a class size target of 60 (modelled on McMaster’s Arts & Science Program) with an emphasis on:

- learning through research and development of research skills and awareness;
- integration of scientific ideas, concepts, and approaches and engagement with the broadest possible range of scientific and mathematical activity;
- science literacy, including science communication, and the need for collaboration skills; and
- development of depth-of-understanding and skills, not just breadth.

The design committee recommended the creation of two teaching track positions to form, in conjunction with the program director, the core faculty responsible for the administration and operation of the program. These positions were filled by Sarah Symons and Chad Harvey in February 2009. By the time these appointments began, the design team had assembled most of the administrative structure, including the overall shape of courses within the program. Each of the four levels within the program would have a single course, within which all the material would be delivered by a multi-disciplinary teaching team in as integrated a manner as possible. In Level 1, the course was named ISCI 1A24. This was equivalent to eight standard 3-unit courses and provided room for a student to take two 3-unit electives. The Level 2 course, ISCI 2A18, was designed to leave space for four electives, and each of the upper levels, ISCI 3A12 and 4A12, was to be accompanied by six electives of the student's choice.

Each level of iSci is characterized and based upon group and/or individual research projects (RPs), culminating in the Level 4 thesis, within which a broad range of subject matter, skills, and approaches are explored. The research projects increase in complexity and flexibility through the levels, with Level 1 projects being short, directed, and more specific in their content (in order to provide equivalency with the curriculum content of standard science courses). Upper-level projects allow students much more choice of methods, topics, and even assessed deliverables.

Level 1 consists of five consecutive research projects:

- RP0: a content-light "practice" group project to introduce structures and procedures in the first 6 weeks of Fall term;
- RP1: a 3-week group project, called Exoplanetary Exploration;
- RP2: a 3-week group project rounding out Fall term, called Drugs, Doses, and Biodistribution;
- RP3: a 6-week group project, Sustainable Energy in Challenging Environments in the first half of the Winter term; and
- RP4: a 6-week group project, What is Cancer?, in the second half of the Winter term.

RPs 1–4 each draw on and motivate content learning and skills in all six of the first-year discipline components (i.e., mathematics, physics, chemistry, life sciences, Earth sciences, and science literacy).

Level 2 has a different structure, with five interdisciplinary research project topics and only three core content threads (i.e., mathematics, science literacy, and laboratory practicum) running in parallel throughout the year. Each group research project runs either intensively for 6 weeks or less intensively for 10 weeks, in either Fall or Winter terms. Similar to Level 1, the RPs in Level 2 cover curricular content equivalent to other Faculty of Science courses, which facilitates Level 3 elective prerequisites, but do so using a research-based structure that exposes students to concepts and research approaches from the following inherently interdisciplinary fields:

- thermodynamics,
- plant-animal interactions,
- Earth history and history of science,
- drug discovery, and

- neuroscience.

The Winter term concludes with a 5-week enrichment project, in which pairs of students choose one of the group project topics and take it further, with a step towards original research.

Level 3 has only five components: three group projects, science literacy, and a one-term independent project (an individual original research project). The overarching group project topics are:

- climate change,
- astrophysics/cosmology/astrobiology, and
- wine and viticulture.

In each case, student groups will design and carry out their own research, teaching, and/or science communication activities. Finally, in Level 4, the students complete an individual thesis and an accompanying skills seminar.

From Level 2, students may choose to take most of their electives within a specific area of science, which leads to a "concentration" in that area (somewhat similar to a combined honours or double major) that is noted in their final degree title. The course list for each concentration is designed by that particular department in the Faculty of Science. Not all students choose to concentrate, but those who do are well-prepared for graduate studies in that area.

The resulting pedagogical framework is unique to the program but firmly based in principles learned through (a) instructors' varied research backgrounds and activities; (b) problem-based learning (PBL) techniques (both as developed originally at McMaster and later European STEM-based variants [Raine & Symons, 2005; Williams et al., 2010]); (c) ideas from co- and team-teaching techniques, student partnership, and real-time feedback; and (d) research-informed practice, including Eyles, Harvey, and Symons' work in developing and enhancing the program via our pedagogical research activities. This list is not in order of importance, but in order of application: the design team started from the point of view of "what scientists need to do," through "how science can be taught" to asking, "are we doing the best we can?"

INTEGRATION OF DISCIPLINARY CONTENT

A major task facing the design team was to find a way of populating the curricula of around 12 standard science courses into the 24-unit format of ISCI 1A24. The curriculum pressure came as a directive from the dean: that a student who had passed ISCI 1A24 should be able to take any Level 2 course in the Faculty of Science. This implied that ISCI 1A24 should serve as a prerequisite (for equivalency purposes) for three math, two physics, two chemistry, two biology, two psychology (together termed life science), and one Earth science course and would also contain important science-literacy and research-skills content which was envisaged as additional to the content that other Level 1 science students would (at the time) have been receiving. This represented a huge challenge for the team.

To meet this challenge, an instructional team, called iTeach, was assembled. To this day, it comprises a truly interdisciplinary set of instructors assigned to teach in iSci from each department in the Faculty of Science. Initially this included several members of the design team to join Eyles, Harvey, and Symons. Fundamental to the original team was that each of the instructors brought experience and insight from teaching equivalent courses from their home departments. This expertise was of paramount importance to the rest of the design phase. In its current structure, iTeach annually includes about 10 disciplinary instructors across the four levels of the program, in addition to the lab coordinator, instructional assistant(s), and TAs.

We should perhaps say immediately that we did not quite fully meet the challenge of integrating all introductory science into one 24-unit course. We were unable to fit enough material to form an equivalency for one of the math courses (MATH 1B03 Linear Algebra). To this day, iSci students who wish to specialise in mathematical areas (including physics) need to take MATH 1B03 during Level 1 or 2.

Continuing with ISCI 1A24 as an example of how we integrate disciplinary content, the remaining material from the pre-existing intro science courses was deconstructed, and we began to identify essential content and skills, compare disciplinary approaches, re-arrange content, and compress the essence of interdisciplinary science into the instructional space available. We mapped the entire Level 1 science curriculum. We spotted as many areas of overlap and integration as possible. As examples, introductory metabolism, which is taught in intro biology, is indeed applied redox chemistry that is covered in intro chemistry; the mechanics of earthquakes covered in intro Earth science is applied Newtonian physics, which is covered in intro physics. These overlaps were then integrated and often covered in co-taught classes (i.e., two instructors collaborating in one class). We encouraged the whole team to be ruthless about cutting out anything but the core fundamentals of their discipline area that were necessary for future growth. We aimed to teach approximately 80% of the material content of each of the standard Level 1 science courses. By reducing the focus on content and eliminating areas of overlap, we were able to build in much more capacity for student development of learning processes and skills. Our aim was to give the students the tools they need to learn, absorb, and research science, and by restructuring the introductory level material, we were able to focus on that far earlier than was traditional in undergraduate programs.

The gains made by identifying disciplinary overlap and reducing non-essential content were then employed in supporting research- and communication-skills development by bringing the integrated content together in thematic, team-based research projects. As mentioned above, RPs are the main learning vehicle for students in Levels 1 to 3 of the program. They range from 3 weeks to 10 weeks long, increasing in complexity, flexibility, and length as students progress (Symons et al., 2017). The first RP, which we call RP0, is a practice or template project to accustom students to the learning and pedagogical structure of iSci RPs. The theme is usually environmental (facilitating field work), but the disciplinary content is minimal: the important learning objectives are fundamental collaboration and project management skills, experiencing various forms of team communication platforms; learning about interactions among instructors, teaching assistants, and students; and learning the basics of what is expected in assessments and deliverables for research projects.

In Level 1, the RPs are more directed: most teams will be working on the same or similar topics. As a general principle, each RP will introduce a variation in the deliverable formats, techniques, opportunity for students to choose their team direction, team sizes or selection, and/or mathematical modelling, laboratory, and field experiences. We use the research projects to demonstrate and require interdisciplinary awareness and thinking to illustrate the importance of skills and professional practices and, above all, to train the students for working in a realistic, team-based scientific environment.

As an example, RP1: Exoplanetary Exploration, provides Level 1 students the opportunity to relate their curricular learning to the socially relevant topic of space exploration and the search for life beyond our own solar system. Students apply the concepts from each of the disciplines: calculating planetary motion (mathematics), gravitational forces (physics), conditions for states of water (chemistry), metabolic signs of life and social psychology (life science), landing sites and geological analogues (Earth science), and sourcing and presenting scientific information (science literacy) to seek understanding of these concepts and how the fundamentals of each relates to a real-world issue. The students are tasked with answering specific modelling questions, generating a potential analogue research mission to Mars, and presenting their research in an oral presentation. The assessment for the project is based upon individual and group-based deliverables which vary in requirement and assessment for each discipline. In order to fulfil curriculum requirements in Levels 1 and 2, the RPs are not summative (i.e., relying on previously acquired knowledge) but are themselves central to student learning. As scientific advancements are made, the tasks and details of the project are updated each year to keep relevance key to the students while still covering the required curricular content.

INTEGRATION AND INFLUENCE VIA COLLABORATION

Collaboration is at the core of iSci. With so many instructors (from many science departments) involved in each level of the program, we must work together closely and effectively. Most instructors who teach in iSci do so because of an interest in teaching in a new and different environment. We share practice, bring in ideas from other courses, and try new methods in iSci which can then be exported to courses with a greater number of students. The iSci teaching team has modified, improved, updated, and refined every aspect of the courses it delivers over the years. Every instructor brings their own unique perspectives, interests, and flavours to the program, creating a dynamic teaching and learning environment that is constantly renewing.

Instructor turnover occurs from year to year as departmental teaching assignments change or instructors change institutions, but this is a net positive influence on the program. The first year of teaching in iSci is (usually) a challenge for instructors; however, due to the intricate relationship between one's own (often discipline-based) teaching, what other instructors are teaching at the same time, and how it is all woven together in research projects, these challenges are met and supported. It is not immediately clear, for example, which parts of an individual instructor's curriculum can be modified or moved to fit with research project themes and which must stay in place as they form a foundation for scaffolded learning.

In the same way, our students are not only learning how to collaborate effectively and fairly with each other but are also our collaborators, providing excellent feedback to improve the program. Science is not an activity carried out alone, so the team-based research projects do not resemble high-school group work but are designed to move students beyond the (perceived) high-school group-work model into professional practices of collaborative working environments and asymmetrical working relationships (such as supervisorial and mentorial) and to appreciate and seek out the advantages of diversity in working teams. In contrast to high-school group work, where students may have had the experience of taking on the bulk of a group project themselves, we incorporate peer evaluation that has an impact on individual grades (meaning that "riding coat-tails" is not a good strategy). Similarly, project members may traditionally arrive with identical prior knowledge. In iSci, students specialise and take different combinations of courses outside iSci, meaning that "subject experts" are part of groups from the second year onwards, which increasingly mirrors real-world collaborative teams.

This emphasis on communities and relationships extends to our efforts to bridge the gap between entry-based cohorts in the program. We were acutely aware that our first cohort of students, who entered iSci in the fall of 2009 (and graduated in 2013,) had no upper years to reassure and guide them. We had to take on this role and could perhaps be described as "helicopter professors" during their first 2 years. However, we did put in place a structure that would form the foundations of the student community. We encouraged the formation of a student society, which immediately initiated a system of student mentorship, matching incoming students with Level 2 students, creating Little/Big Sib partners (similar to McMaster's Arts & Science Program). We also strengthened opportunities for inter-cohort interaction in the curriculum, requiring students in Levels 1 and 2 (and then Level 3 the following year) to complete short writing assignments in the form of scientific blog posts, which are not visible to the public but are open for comments from the whole iSci student body. Thus, an incoming student writing their first blog post can be given feedback from a Level 3 student, which they can use to polish their piece before it is marked (students also receive a mark for providing this feedback). As students choose their own topics and make connections between scientific ideas and (for example) topical events or personal interests, this provides a way of getting to know the interests of other students and, crucially for all involved, allows students to practice their proofreading, editing, and feedback-writing skills. In this way, students receive far more feedback on their writing and communication skills than we as instructors could ever afford to give them.

In 2013, we added a final in-program bridge between cohorts: our undergraduate student research symposium *Synthesis*. This annual event, held in April, is organised by the student body (Levels 2 and 3 take the lead) and populated by oral and poster presentations by students (abstracts are peer reviewed by students, of course), events, and invited speakers. Students from our cousin programs in Canada and the UK are now able to attend (in person or virtually) and contribute to the proceedings. All our Level 4 students present their thesis research at the symposium, allowing Level 1 students to see exactly where they will be and what they can achieve in 4 years.

What we did not plan or expect was the level of interaction and community-building that the student body would engage in themselves. From tutoring, advice, and study groups through to social events, competition teams, and artistic endeavours, the program's community spirit is extremely high. The students (and instructors) take pride in and value the importance of this community within the program. Having small cohorts of students inherently helps establish this level of community, but Big Sibs and student leaders make concerted effort to communicate to incoming students how the collaboration and communication that the community generates will positively influence their academics, which is further reinforced in the collaborative structure of research project groups. When we celebrated our 10th anniversary with a gala dinner in February 2020, it was delightful to see how many alumni our current students already knew by name and reputation, as they had already been giving advice, re-visiting campus, or had kept in touch with their Little/Big Sib partners and extended Sib families.

INTEGRATING SKILLS VIA SCIENCE LITERACY & COMMUNICATION

Starting from the initial design and vision of the program, there was a plan for incorporating writing, communication, career development, and library skills as a central theme or spine. The first iteration was found to be too heavy on reading time for a busy science undergraduate. The pattern which emerged from the second run was to front-load these skills in Level 1 by dedicating 2 hours of class most weeks of term to the "science literary" component (known as SciLit). This component runs alongside and serves the research projects and the other five discipline components. Science literacy skills are introduced by looking at the way science works in academia, industry, and society. We cover the fundamentals of information handling in science, comprising the following functional areas: *input*, in the form of finding, evaluating, and reading literature; *process*, involving using information, designing experiments, peer review, funding, and standards of professional behaviour such as ethics; and *output*, including writing, citing, speaking, and designing images, slides, and posters. Alongside these, we also set the scene for career development skills, such as developing relationships with future references, preparing for interviews, completing applications, and updating CVs/resumes. In Level 1, all of these topics are starting points which will be further developed and refined throughout the program. Basic writing and citing skills are developed via the blog drafting system described above. The research projects provide the motivation and practice for much of the science literacy content, with RP deliverables being varied and designed to cover a wide range of communication scenarios and strategies throughout Level 1 to 3 of the program.

After Level 1, there are no more scheduled SciLit classes. The SciLit component in Levels 2 and 3 is assessed via a portfolio of work, but with flexibility of timing and direction within each term. Students continue to write at least two blog posts a year to provide them with at least eight pieces of comparable individual writing during iSci. This allows them to see their own work in a long-term context. The *Synopsis* blog is only visible to the iSci community. At their request, any finished blogpost can be copied to the public side of the *Synopsis* blog to allow student to showcase their writing and refer to it in their resumes. The portfolio allows students to include extracurricular scientific presentations, knowledge translation projects, and teaching to be taken into consideration for grades via reflections on these activities. Students can also request feedback from the SciLit instructor or TAs on iSci work and on their resumes in order to have access to one-on-one or group-based tutoring specific to their needs. This portfolio system allows students to build their skills at their own pace and takes into account both their common background of Level 1 SciLit and their increasingly different scientific pathways and interests as they progress through their degree.

Many themes from science literacy are revisited in the Level 4 seminar which runs alongside the final thesis that all iSci students complete (i.e., ISCI 4A12 is broken into a 9-unit thesis and 3-unit professional development seminar). Although science literacy is not a separate component in Level 4, working on a thesis and applying for their next academic and/or career step brings together all the skills that the students have practiced throughout their degree. In particular, being familiar with skills such as writing a literature review, keeping a research notebook, and designing a conference poster stand students in good stead for their thesis, allowing them time to focus on the science itself but also to reflect on the experience in relation to their future aspirations. We regularly receive unsolicited positive feedback from independent research and thesis supervisors regarding iSci student analytical and research skills as well as their ability to write and effectively present their research.

LONGITUDINAL RESEARCH: WHAT IS THE IMPACT AND INFLUENCE OF THE ISCI PROGRAM?

One of the clearest examples of integration and influence that has emerged from the program is our longitudinal pedagogical research study that we initiated in Spring 2012. As a new program with an innovative structure, we needed to evaluate and assess whether it was working—literally asking the question “Is iSci successful?” The key to answering this question has been concentrating on the student perspective. The longitudinal study is based upon a series of surveys that gather student perceptions across their time in the program: at entrance to the program, at the end of Levels 1, 2, and 3, as well as at graduation. In 2014 we added an additional survey to collect alumni perceptions of how the program aided (or not) their post-graduate career path. We initially sought this feedback at 1-, 3-, and 5-years post-graduation but have changed to an annual model where alumni indicate time since graduation. In 2015 we also extended the study to collect comparative data from students in other undergraduate programs in the Faculty of Science at McMaster.

Using an individual identifier code, we can track changes in student perception across levels of study for the same facets of the program using questions about engagement, learning facilitation, skill generation, and whether they feel the program has prepared them for their next academic step, whether that be moving from Level 1 to Level 2 or to post-graduate study or employment. All the data we collect is aggregated for emergent trends but can be modified for research questions which require different types of comparison. For example, we can compare student perception within a cohort, such as by concentration, or across levels, such as Level 1 to 3 student perceptions versus that of graduating students.

The survey instruments are quite exhaustive, so we (willingly) allocate class time for information sessions as well as time to complete the survey instruments. The instruments themselves have evolved along with the program as we have removed or added components. We have, on request, shared our instruments with our cousin programs at the University of British Columbia, Western University, and the University of Leicester as a step towards a larger evaluation of integrated science programs.

The data that we have gathered over the past 10 years demonstrate four main areas of influence that have aided the substantiation of the iSci Program:

- rapid adaptation from student feedback,
- design validation: group work and skills-integrated curriculum,
- validation of longitudinal program evaluation (i.e., not just course evaluations), and
- increased student awareness of learning: theirs and others'.

Early findings from the longitudinal study were constructive and influenced additions to the curriculum that students felt were lacking; as an example, across levels, students perceived there was not enough exposure to computational software and modelling. As a result, we have embedded more use of agent-based modelling (with NetLogo), coding (with Python), and statistical analysis (with R). These additions have improved student perceptions of their preparedness for upper-level computational courses, data analysis for research projects, and post-graduate careers.

The design of the iSci pedagogy centres upon students learning through collaborative, group-based research projects. Despite the reality that most professionals work within collaborative teams, group work is often seen as a negative experience for most undergraduate students. By teaching iSci students, starting early in their first year, with a skills-based approach how to perform, manage, and communicate in collaborative groups, iSci students have exhibited a significantly higher engagement in group research and a significantly higher perception of how it facilitates their learning than students in other programs in the McMaster Faculty of Science (Gretton et al., 2022).

Using a longitudinal study that collects student perceptions across years, as opposed to annual course evaluations (which still occur for university purposes), we have identified some trends that greatly reinforce program innovations. As an example, Level 1 students found the science literacy component the least engaging; however, by Level 3, students feel Level 1 science literacy is one of the most important and useful aspects of the program—a significant and unforeseen comparative trend.

With the ever-present goal of integration, we not only seek student participation in the study, but we present the idea of participation, the idea of the study itself, and its results as a vehicle that exposes students to another form of scientific research. Exemplifying the influence this experience has, we annually have iSci students undertake their own pedagogical study as part of their Level 2 or 3 independent research project or for an honour's thesis in Level 4.

The longitudinal study has not only been fruitful for course evaluation, adaptation, and validation. We have used the data in the scholarship of teaching and learning to its fullest extent, presenting results in reviewed and invited conference talks across the globe, as well as several collaborative publications (e.g., Gretton et al., 2022; Hurkett et al., 2018; Symons et al., 2017; Williams et al., 2020) that demonstrate the innovation of the iSci model in its utility for student learning and skill development, collaborative instructor pedagogy, student-partnered research, instructor professional development, and program administration.

CONCLUSIONS

The Honours Integrated Science Program at McMaster was the first of its kind in Canada. It has now graduated over 340 students who have entered a range of post-graduate careers in academia, industry, medicine, and law. Our original intention in creating the program was to prepare students for a broad range of careers in an equally broad range of scientific (or non-scientific) disciplines. In this we have been successful. Our focus on the development of a pedagogical approach and program structure that allows students to explore, develop valuable skill sets, and appreciate the interweaving of scientific concepts and approaches from multiple disciplinary perspectives has allowed the production of confident graduates equipped to enter many fields. This learning strategy has not only had a positive influence on our students but has also greatly impacted members of the instructional team who find teaching in the iSci Program invigorating and exciting. The iSci Program is not static, it is a nimble and dynamic program that is constantly evolving in response to both internal and external influences, such as changing student demographics, recruitment pressures, institutional financial health, scientific advances, and (of course) global issues such as COVID-19 and climate change. Over the past decade there has been observable and growing development of interdisciplinary programs that allow students to cross traditional disciplinary boundaries and that provide an education appropriate to addressing the complex and dynamic societal issues that we are facing currently and will face in the future (Feder, 2021). In this context, the Honours Integrated Science Program at McMaster truly is a science program for the 21st Century.

NOTE ON CONTRIBUTORS

Dr. Sarah L. Symons *is a professor in the School of Interdisciplinary Science and the current coordinator of the Honours Integrated Science Program. Dr. Symons is a recipient of a 2022 President's Award for Outstanding Contributions to Teaching and Learning at McMaster. She has been involved in curriculum design and pedagogical innovation in higher education for 20 years. Her teaching interests include science literacy, science communication, and history of science. In addition to pedagogical research, she also works on the origins of timekeeping and astronomy, with a focus on ancient Egypt.*

Dr. Chad T. Harvey *is an associate professor in the School of Interdisciplinary Science. He conducts pedagogical research on research-based learning, bridging the research-teaching nexus, and the student transition to post-secondary education. He is the recipient of the 2016 Ontario University Student Alliance Teaching Award and a 2017 President's Award for*

Outstanding Contributions to Teaching and Learning at McMaster. His other research areas assess the impacts of invasive species and urbanisation on biodiversity and food web resilience.

Dr. Carolyn H. Eyles *is a professor in the School of Earth, Environment & Society and the School of Interdisciplinary Science at McMaster University. She holds a B.Sc. in Environmental Sciences, a postgraduate Certificate of Education, and an M.Sc. and Ph.D. in Geology from the University of Toronto. She is certified as a professional geoscientist in Ontario and is a 3M national teaching fellow. She is a recipient of the 2022 Professional Geologists of Ontario Award of Merit for her teaching and training of graduate and undergraduate geoscience students. Her research involves analysis of glacial sediments and their origin. She has been a faculty member at McMaster since 1988 and has been involved in many course and curriculum design initiatives for the Faculty of Science.*

REFERENCES

Eyles, C. H., & Racine, R. J. (2007). *Honours Integrated Science design document*. http://hdl.handle.net/11375/14501

Feder, T. (2021). Undergraduate integrated science programs foster interdisciplinary and personal connections. *Physics Today*, *74*(10), 22-25. https://doi.org/10.1063/PT.3.4853

Gretton, S. N., Harvey, C. T., Raine, D. J., Hurkett, C. P., Williams, D. P., & Symons, S. L. (2022). Revisiting the research-teaching nexus framework: Two case studies introducing research into programme level, undergraduate teaching. *International Journal of Teaching and Learning in Higher Education*, *33*(2), 259–272. https://www.isetl.org/ijtlhe/pdf/IJTLHE4019.pdf

Hurkett, C. P., Symons, S. L., Gretton, S. N., Harvey, C. T., Lock, P. E., Williams, D. P., & Raine, D. J. (2018). The benefits of sustained undergraduate inter-programme collaborations between international partners. *Journal of Learning and Teaching in Higher Education*, *1*(1), 31–42. https://core.ac.uk/download/pdf/267013986.pdf

Raine, D., & Symons, S. L. (Eds.). (2005). *PossiBiLities: A practice guide to problem-based learning in physics and astronomy*. The Higher Education Academy Physical Sciences Centre. https://hydra.hull.ac.uk/assets/hull:4541/content

Symons, S. L., Colgoni, A., & Harvey, C. T. (2017). Student perceptions of staged transfer to independent research skills during a four-year honours integrated science undergraduate program. *Canadian Journal of Scholarship of Teaching and Learning*, *8*(1). https://doi.org/10.5206/cjsotl-rcacea.2017.1.6

Williams, D. P., Hurkett, C. P., Symons, S. L., Gretton, S. N., Harvey, C. T., Lock, P. E., & Raine, D. J. (2020). A framework for student-instructor partnerships. *International Journal of Teaching and Learning in Higher Education*, *32*(3), 454–462. https://files.eric.ed.gov/fulltext/EJ1299977.pdf

Williams, D. P., Woodward, J. R., Symons, S. L., & Davies, D. L. (2010). A tiny adventure: The introduction of problem based learning in an undergraduate chemistry course.

Chemistry Education Research and Practice, *11*(1), 33–42. https://doi.org/10.1039/C001045F