



Andrew Perrella, MCMASTER UNIVERSITY, andrew.perrella@medportal.ca

Huyen Dam, MCMASTER UNIVERSITY, damhd@mcmaster.ca

Lynn Martin, MCMASTER UNIVERSITY, martl@mcmaster.ca

John MacLachlan, MCMASTER UNIVERSITY, maclacjc@mcmaster.ca

Nancy Fenton, MCMASTER UNIVERSITY, fentonn@mcmaster.ca

Between Culture and Curricula: Exploring Student and Faculty Experiences of Undergraduate Research and Inquiry

ABSTRACT

Undergraduate research and inquiry is a growing movement within the teaching and learning nexus, with many institutions developing their practices within this culture of education. This study aimed to identify the perceptions and experiences surrounding undergraduate research and inquiry among students and faculty at McMaster University in Ontario, Canada; assess the extent of research and inquiry in the design of undergraduate courses; and explore the facilitators and obstacles educators encounter when attempting to implement this educational approach. Although differences exist in student and faculty definitions of undergraduate research and inquiry, we found two principal models that characterize its structure and delivery—the *scaffold model* and *bookend model*. A third, the *abstract model*, does not employ the practice of inquiry. Despite numerous benefits unique to undergraduate research and inquiry education identified by stakeholders, notable barriers (such as funding, faculty buy-in, limited student experience, and inherent competition) hinder its progress. Overall, we found a diversity of undergraduate research and inquiry practices across the university, operating within varying cultures and comfort levels, which suggests unequal access for student learners.

KEYWORDS

inquiry-based learning, undergraduate research, teaching-research nexus, student-centered learning, pedagogy research

INTRODUCTION

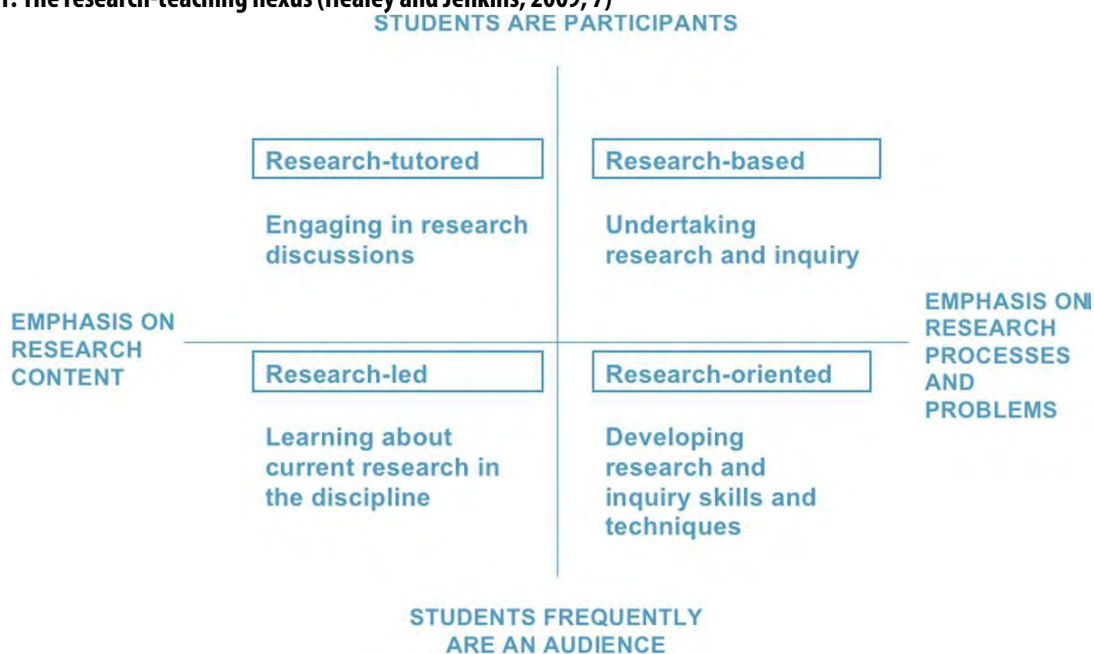
In 1998, the Boyer Commission on Educating Undergraduates in the Research University called for academic institutions to search for a new, shared mission grounded in “a deep and abiding understanding that inquiry, investigation, and discovery are the heart of the enterprise” (9). The current pedagogical direction of undergraduate research and inquiry has advanced internationally, with curricular shifts seen in the United Kingdom, China, Australia, and Africa (Blackmore and Kandiko 2012). In this article, we describe our findings from a study of the perceptions about and experiences of undergraduate research and inquiry of faculty and students across a range of disciplines at McMaster University, a medium-size, research-intensive university in Canada.

Over the past two decades, there has been a focus on defining approaches to the integration of research, teaching, and learning, with general agreement on four main approaches: learning about others' research, learning to do research, learning through the research process, and pedagogic research (Healey 2005, 69–70). Evidently, it is through the former three routes that students learn and experience research.

Once undergraduate research has been integrated into the institution as a whole, the question should be asked: “what is the undergraduate student research experience?” To address that question for our institution, we used Mick Healey’s (2005) framework to guide our analysis and interpretation of our research findings. Healey specifies four approaches to curriculum design that involve undergraduate students in research: (1) research-led, (2) research-oriented, (3) research-based, and (4) research-tutored (Healey 2005, 70). Healey and Jenkins (2009, 7) represent visually this teaching-research nexus, highlighting the efficacy of engaging students in active, research-centered teaching that moves away from the dichotomous relationship between teaching and research as two separate academic activities (see figure 1). Most educational institutions operate within research-led and research-oriented curricula where students remain as passive participants in the research process. In research-intensive universities, academics perceive the *linking* of research and teaching as beneficial to students (Elen and Verburgh 2008, 68). Optimally, *research-based* curricula involve students as active participants in the research, with varying emphasis on research processes, critical thinking, and problem-solving.

While a large body of research supports the evidence-based practices of inquiry-led and research-led curricula, there is less work emphasizing the nexus between undergraduate research and inquiry (Healey and Jenkins 2009), and even less work that sheds light on the variability between students and faculty members’ perceptions of undergraduate research and inquiry. Our study explored the meaning and experiences of faculty, and undergraduate students’ perspectives on undergraduate research and inquiry—including how it is accessed and delivered—from a range of disciplines.

Figure 1. The research-teaching nexus (Healey and Jenkins, 2009, 7)



Defining undergraduate research and inquiry

The terms *inquiry* and *research* are often used interchangeably in the literature (some examples are the Boyer Commission 1998; Levy and Petrulis 2012; Pedaste et al. 2015; Spronken-Smith and Walker 2010). *Inquiry*—or inquiry-based learning, as it has come to be known (Pedaste et al. 2015)—is centered on finding solutions to real problems by asking and refining questions, designing and conducting investigations, gathering and analyzing information, drawing conclusions, and reporting findings (Lee, Myatt, and Joughin 2012; Pedaste and Sarapuu 2006; Staver and Bay 1987). In his original conception of problem-based learning—the most scrutinized approach to inquiry—Howard Barrows (1996) argues that small-group learning under the guidance of a tutor who acts as a facilitator is a core characteristic of this approach. At its heart, inquiry-based learning aspires to engage students in an authentic scientific discovery process (Pedaste et al. 2015). However, settling on one unified definition has proven challenging, as the term *inquiry* itself is not used consistently throughout the educational literature. For instance, it has been described as “enquiry-based learning,” “guided-inquiry,” “inquiry-guided learning,” “problem-based learning,” “undergraduate research,” and “research-based teaching” (Barrows 1996, 5–6; Spronken-Smith and Walker 2010, 725–27). Beyond a definition, various inquiry approaches to education have also been described, including “authentic intellectual work” (Newmann, Bryk, and Nagaoka 2001), “project-based learning” (Thomas and Mergendoller 2000), and design-based learning (Hmelo, Holton, and Kolodner 2000, 249). As Alan Colburn (2000, 42) simply suggests, “the most confusing thing about inquiry is its definition” because *inquiry* “is used to describe both teaching and doing science.”

John Staver and Mary Bay (1987) initially broadened the notion of inquiry by categorizing the teaching (or “mode”) of inquiry in three different ways. In *structured-inquiry*, teachers provide an issue and an outline for addressing it, whereas in *open-inquiry*, students navigate their own learning on a topic by formulating the question and working through the inquiry cycle themselves. In between is a *guided-inquiry*, wherein teachers provide questions to facilitate a structured learning pathway for students, thus maintaining continuity within the research process (Spronken-Smith and Walker 2010; Staver and Bay 1987).

The trend toward involving students in curricular discussions and the teaching-research nexus is a more recent phenomenon (Healey et al. 2010). Several scholars have looked at the experiences of first-year students with inquiry-based learning (Cox et al. 2008; Justice et al. 2007; Levy and Petrulis 2012), while others have looked solely at final-year students (Healey et al. 2010; Short, Healey, and Romer 2010; Turner, Wuetherick, and Healey 2008; Visser-Wijnveen et al. 2012), postgraduate students (Deem and Lucas 2006), faculty researchers (Myatt and Jones 2015), or single departments (Buckley 2011; Visser-Wijnveen et al. 2012) in discussing the student research experience. Furthermore, even though no clear definitions of inquiry and research exist that reflect the breadth and depth of the undergraduate student experiences, there is some agreement that institutions should develop an inclusive construct that values a range of practices that best fit the campus culture and institutional mandate (Beckman and Hensel 2009; Kinzie, Husic, and Elrod 2010; Jenkins and Healey 2012).

At the intersection: Undergraduate research and inquiry

In our study, we employed a purposive amalgamation of *undergraduate research* and *inquiry* into one concept—undergraduate research and inquiry—which is philosophically grounded in capitalizing on the synergistic relationship between faculty and students to create and support the institution’s

commitment to intellectual investigation and discovery. Janet Donald's seminal work, "Learning to Think: Disciplinary Perspectives" (2002), is one of the first to explore the commonalities in inquiry methods across a variety of university undergraduate disciplines, the gap between the curriculum that faculty intend, and the curriculum that students experience. She further highlights that "research" and "inquiry" are connected to the idea of producing *authentic intellectual work* (Donald 2002). Under a framework of undergraduate research and inquiry, the inextricable relationship between research and inquiry allows them to be understood as one entity, with the aim of aligning curricular goals and curtailing the aforementioned inconsistencies in how these terms are employed. Furthermore, this conceptualization of undergraduate research and inquiry adds a pivotal aspect of *engagement* in student learning and student-centered research. Students involved in undergraduate research and inquiry learn the skill of asking research questions, not in a disciplinary vacuum, but within the context of "triggers" (that is, course themes) (Cuneo et al. 2012, 95). Overall, learners involved in undergraduate research and inquiry have reported greater enhancement of cognitive and personal skills, higher levels of engagement, increased academic success, greater satisfaction with their undergraduate education (Wayment and Dickson 2008; Zimbardi and Myatt 2014), and confirmation of future career plans (Hunter, Laursen, and Seymour 2007).

Institutional context

McMaster University, in Ontario, Canada has approximately 950 full-time faculty members from six faculties: the DeGroot School of Business, the Faculties of Engineering, Health Sciences, Humanities, Science, and Social Sciences. As of 2018, there were 26,780 undergraduate and 4,485 graduate students enrolled, for a total student population of 31,265.

In 1981, the Arts and Science program was founded as an innovative program that focused on learning through inquiry in an interdisciplinary context. While inquiry is not new, developing a teaching method that was congruent with student-focused learning objectives and assessment was indeed innovative at the time. Over the next decade, inquiry-based ideologies permeated the departments of engineering, humanities, and social sciences (Cuneo et al. 2012). In 2000, a new inquiry-based Bachelor of Health Sciences degree program that institutionalized inquiry across a wide variety of courses from first to fourth year levels was established. This institution has been recognized for its "innovative and effective comprehensive strategies that promote undergraduate research and inquiry" (Healey and Jenkins 2018, 58).

In 2014–15, research working groups made up of students, faculty, and staff were established to develop recommendations for scholarship in six broad areas, one of which was undergraduate research and inquiry. It had been long theorized that this approach holds great potential as a driver for the student experience, as well as opportunities for learning. Thus, the aim of our study was to determine what practices and policies already existed, and explore faculty and student perspectives and experiences of undergraduate research and inquiry. We examined these elements to provide a rich understanding of how practices of research and inquiry were implemented, and where opportunities for growth exist.

METHODS

Our study was designed as qualitative, exploratory research employing one-on-one interviews with key faculty members and focus group discussions with undergraduate students. All participants provided informed consent. All interviews and focus groups were audio-recorded, transcribed verbatim,

and anonymized. NVivo Software Version 11 (QSR International) was used to manage the data and facilitate coding and analysis. The study was approved by the university’s Research and Ethics Board.

Data collection

In January and February 2016, four focus groups were conducted with a total of 20 undergraduate students (first to fourth years) from various departments (sociology, 4; geography, 5; health sciences, 6; communications, 1; political science, 2; biology, 1; and engineering, 1) in order to explore student perceptions of undergraduate research and inquiry within and beyond their curricula (see table 1). Students were recruited through public advertisements and in-class announcements. All undergraduate students were targeted in the recruitment strategy. Following H. Russel Bernard (2017, 163–94), we used 60- to 75-minute focus group discussions to collect perspectives through semi-structured questions, gathering rich data about the student experiences of undergraduate research and inquiry. The interview protocol was pilot tested with a subset of students and revised to ensure clarity of questions (see the student focus group protocol in appendix B).

Table 1. Distribution of student participants across focus groups

Focus group 1	Focus group 2	Focus group 3	Focus group 4
Sociology (year 2, year 4) Geography (year 3) Health sciences (year 2) Communications (year 3)	Geography (year 2, year 3, year 3) Sociology (year 1, year 2) Political sciences (year 2, year 2)	Health sciences (year 2, year 3, year 3, year 3, year 3) Biology (year 4)	Geography (year 4) Engineering (year 4)

From May to December 2016, one-on-one interviews were conducted with 12 faculty members (who we called “key informants”) representing all six faculties from across the university. We targeted between 13 and 19 interviews across the six faculties, with 12 total responses. We used a purposive sampling strategy to recruit department chairs, or otherwise senior faculty with a minimum of 10 years as educators in their department, who could best speak broadly on issues pertaining to undergraduate research and inquiry. It was felt that the participation of these senior faculty as key informants would elicit the most accurate representation and sentiments of the current climate of their respective departments, drawing on both their experiences (through seniority) and the continual input and feedback received from faculty members. Extensive efforts (email, in-person contact) were made to accrue participation from departmental chairs, or surrogate key informants, from each faculty. Following Bernard (2017, 163–94), semi-structured interviews (45–60 minutes) were used to capture the breadth and diversity of curriculum-based undergraduate research and inquiry experiences. This allowed room for participants to provide more detailed information, and to discuss salient topics beyond the scope of the interview questions. The interview protocol was pilot tested to ensure clarity of questions. The research questions focused on faculty experiences of undergraduate research and inquiry; the practices, processes, and resources organized to support it; the avenues to strengthen curriculum design; and the barriers that impede this approach (see the faculty interview protocol at appendix A).

Data analysis

The data collected were analyzed using thematic analysis (as described by Robert Thornberg and Kathy Charmaz 2014). All transcripts were independently analyzed and coded by a minimum of three research team members through line-by-line coding. Data analysis occurred concurrently with data collection and informed subsequent interviews/focus groups. Initial codes were compared among the research team members, with themes identified and discussed through an inter-rater group coding process to increase rigour. Consensus was achieved and overarching themes were finalized. As explored by Tracy Farmer, Kerry Robinson, Susan Elliott, and John Eyles (2006), the exploration of convergence, complementarity, and dissonance in the emerging themes contributed to the triangulation of our data in order to gain a thorough understanding of undergraduate research and inquiry at our institution.

RESULTS

In general, the data showed diversity among students and faculty members in how undergraduate research and inquiry was perceived and experienced. Overall, there existed much diversity in how the approach was operationalized and the degree of variation among disciplines, with curricular design serving as the driving factor. Below, we discuss what emerged from our data under three models illustrating the range of implementation of undergraduate research and inquiry and its practices: the *scaffold* model, the *bookend* model, and the *abstract* model. Briefly, the *scaffold* model describes programs with an enduring culture of undergraduate research and inquiry by means of its integration throughout entire undergraduate curricula, the *bookend* model focuses on programs that focus primarily on early introduction and future application of undergraduate research and inquiry practices, and the *abstract* model characterizes those programs that view undergraduate research and inquiry as a purely theoretical concept with no overarching design or delivery structure. Each of these models has four main themes (1) perceptions of undergraduate research and inquiry, (2) structure and delivery, (3) barriers and limitations to opportunities, and (4) value.

In addition to the range of structure and delivery of undergraduate research and inquiry as described above, the larger conceptualizations of these models are presented in the following section and summarized in table 2.

Table 2. Key informant (KI) participants, their respective departments, and the models of undergraduate research and inquiry endorsed

Models	Perceptions	Barriers and limitations	Value
<p>Scaffold model</p> <p>KI 1: Health sciences KI 4: Biochemistry KI 6: Integrated sciences KI 7: Nursing KI 10: Arts and science</p>	<p>Flexible and student-oriented</p> <p>Viewed as one concept</p> <p>Emphasis on process over product</p>	<p>Human resources</p> <p>Need for flexibility</p> <p>Onboarding new faculty</p> <p>Student vetting process</p>	<p>Unique skill sets</p> <p>Resilience</p> <p>Preparation for graduation</p> <p>Instrumental to success</p>
<p>Bookend model</p> <p>KI 3: Geography and earth sciences KI 5: Social sciences KI 8: Communications KI 9: English</p>	<p>Inquiry as a means to research</p> <p>Supervision</p>	<p>Funding</p> <p>Sustainability</p> <p>Large cohorts</p> <p>Lack of student awareness and mentorship</p>	<p>Skills transferred beyond student undergraduate education</p> <p>Critical and analytical skills</p>
<p>Abstract model</p> <p>KI 2: Software engineering KI 11: Business KI 12: Management sciences</p>	<p>Outcome-oriented</p> <p>Independent of uniqueness</p> <p>No definition of undergraduate research and inquiry provided</p>	<p>Lack of culture</p> <p>Lack of student contribution and utility</p>	<p>Labour for other departments</p> <p>Minimal values identified</p>

Scaffold model

(1) Perceptions

When asked, “What does undergraduate research and inquiry mean to you?”, some students and faculty members separated the two concepts before viewing them as one. In these cases, the experiences of undergraduate research and inquiry among participants depended upon the extent to which undergraduate research and inquiry was embedded within the department pedagogically.

In this model, inquiry was described as a flexible, student-centered, and student-driven approach to learning. It constituted two principle components: formulating a research question and finding an answer. As one student noted, “I see inquiry as the whole process of developing a question and figuring out, mostly independently, how you can gather information, and then answer it” (undergraduate student, health sciences, year 3).

Faculty members largely agreed that inquiry was a process of information retrieval and conceptualization, yet some differentiated *research* from *inquiry* on the basis of knowledge expansion: “I would say that research is geared more toward development of new knowledge or an expansion of understanding. Whereas inquiry is more geared toward expansion of knowledge in the individual” (faculty member, health sciences). For these faculty members, research was understood as a “guided inquiry” (health sciences, integrated sciences, biochemistry, arts and science) with the end-goal of student learning. This was preliminary evidence of the incorporation of an inquiry-mindset in the way departments view undergraduate research. As one faculty member explained, “Inquiry in my experience can be a completely open inquiry, where a student has a question that they would like answered. Of course, we want to keep it within the realm of biochemistry. To me, now we're guiding the inquiry . . . towards a specific topic” (faculty member, biochemistry).

In amalgamating the two concepts—*inquiry and undergraduate research*—the majority of these students understood undergraduate research and inquiry as a *process*, which involved “engaging [oneself] in the academic literature in a specific field of academic study” (undergraduate, health sciences, year 2) and acquiring data to answer a learning objective.

(2) *Structure and delivery*

For programs wherein the culture of inquiry was longstanding, introducing inquiry in the first year of undergraduate studies was common, and mandatory inquiry and research courses permeated the undergraduate curricula from years one to four. In this case, inquiry was described as a “*scaffold approach*” (faculty member, nursing) with students continuously building upon the knowledge and skills acquired in the previous years' experiences. Another faculty member expanded on this: “We try to introduce the students to inquiry and research methodologies in a *scaffold* way. We start at the beginning of first year by having the students complete a research project protocol. They identify what is known, what they have to find out . . . and then they have to go and actually conduct the research” (faculty member, integrated sciences). In this *scaffold* approach, experiences with undergraduate research and inquiry consisted of independent projects, longitudinal group-based projects, and thesis courses during which students gradually acquired and developed critical thinking skills. This approach was “part of the culture and the core curriculum” (faculty member, biochemistry) and the essence of teaching: “that’s what we’re here for” (faculty member, health sciences).

(3) *Barriers and limitations to opportunities*

Numerous barriers hindered the equal diffusion of opportunities for undergraduate students to participate in research and inquiry. Within the *scaffold* model in particular, limitations in funding and resources served as the predominant faculty-level barriers.

A small student-to-faculty ratio was viewed as quintessential to the success of undergraduate research and inquiry, allowing for flexibility and adaptability of education design and pedagogical approach: “I think inquiry works best when you have a fairly small ratio of facilitators to students, because you need to be able to have real dialogues. You need a facilitator to be able to ask probing questions, and that takes time. It takes relationships. It’s not something you can do when there's one instructor and 400 students” (faculty member, health sciences).

Faculty members from programs that were specifically designed for undergraduate research and inquiry tended to have smaller cohorts (60–80 students), which provided faculty members with greater

pedagogical flexibility, as described by one participant: “We get away with a lot. We're not very constrained by the old discipline requirements, so we can break through the concept of what is expected of a physics graduate or chemistry graduate . . . We can also experiment with new pedagogical approaches, which is very fortunate” (faculty member, integrated sciences). This faculty member was speaking from experience in the integrated sciences program, a selective-entry, interdisciplinary, research-based program that focuses on the development of self-directed learning skills through projects and coursework integrating the various science disciplines—chemistry, environmental sciences, psychology, and so on.

To increase access to undergraduate research and inquiry, another faculty member discussed providing students with course credit, and thus incentive, for their self-initiated projects: “People are doing cool stuff and they do it on their own time. If we had some way to give them credit for what they're doing within their degree requirements . . . instead of taking an elective, they could go do what they love doing” (faculty member, arts and science). Furthermore, new faculty participants expressed more uneasiness with the lack of “content” being taught to students within an inquiry-based approach. Their discomfort arose in part with being new faculty members, as well as new to inquiry-based learning. Few had experiences in *inquiry-style classrooms* as students themselves, and thus were unfamiliar with how to instruct in this manner. Faculty members in this model seemed able to articulate this limitation and were willing to work with faculty and department members on the issue. This is in contrast to the *abstract* model, in which lack of comfort with inquiry precludes any progress, as one faculty member commented: “One of the issues around inquiry-based learning that serves as a barrier is uneasiness for many faculty about shifting the emphasis away from content. I think very often people feel like there are just some things you need to know” (faculty member, health sciences). Another said, “People love the idea [of inquiry,] but think: ‘How do I do it?’ Because it's a foreign concept still to a lot of people . . . We typically teach how we were taught” (faculty member, biochemistry).

The students in the *scaffold* modeled programs reported that early access and exposure to research—either through self-directed investment or mandatory project undergraduate courses—was highly beneficial. Yet students readily acknowledged the personal initiative, effort, and ‘push’ required to pursue such opportunities: “There are a lot of project-based courses that offer lots of opportunities to engage with professionals in that field . . . if there is an opportunity and if you feel that you are interested in something, I think we've built a culture in our program where you can help others with that, but it's pretty much an independent process of you having to figure it out what you like and sort of pushing it for yourself” (undergraduate student, health sciences, year 2).

Finally, if a research opportunity was known, students spoke of a “vetting process” that was involved in acquiring such positions: “It is very competitive because as a student, you don't have the skillset to work with the wet lab instrumentation. You are often a burden to peoples' labs. As a first-year, second-year or third-year undergraduate student with very little wet lab experience, it is difficult to become a valuable employee” (undergraduate student, health sciences, year 2).

(4) Value

Undergraduate research and inquiry-based programs appear to promote unique student skill sets: formulating research questions, searching research literature, troubleshooting, developing time management skills, and collaborating with others: “Knowing how to do literature reviews and to critically appraise literature is important to develop your critical research lens . . . You also learn to work

with a research team in a non-structured course environment” (undergraduate student, health sciences, year 2).

One crucial skill—a sense of resilience—was identified as a key, positive outcome of inquiry learning: “I think resilience is a huge one. Generally, you fail many more times than you get the results that you want. I think that's the first exposure to that kind of repetitive failure and troubleshooting for a lot of students, and I think that's a valuable life skill and research skill even after you leave undergrad” (undergraduate student, health sciences, year 3).

Faculty agreed that the processes of undergraduate research and inquiry, unlike didactic instruction, fostered one’s “comfort with uncertainty and intellectual humility” (faculty member, nursing), and agreed that undergraduate research and inquiry developed collaboration skills critical to success in the real-world environment: “The teamwork and the group skills they learn are so important for functioning as successful students beyond the classroom” (faculty member, health sciences). They elaborated that inquiry provided students with a means of negotiating the research process with adaptability, which would ultimately lead to a more stimulating and worthwhile learning experience: “We think it’s the best way for students to learn, to be honest. I think it makes the learning of science exciting. That makes it stimulating. It makes it relevant. Students get why we’re doing this. It’s not easy, but we think that we’re giving them the best start we could possibly give them in terms of their future careers . . . It’s part of our philosophy. We love doing it” (faculty member, integrated sciences).

Bookend model

(1) Perceptions

A definition of undergraduate research and inquiry (URI) was more difficult to pinpoint from some participants, suggesting the concept may not have permeated all departments: “I’ll be honest and say that I’d really never come across the URI acronym before . . . certainly, undergraduate research, certainly inquiry, but never really seen it as a complete entity . . . it’s a little bit of a new lexicon. I’m certainly not seeing it used within the faculty” (faculty member, geography).

Students with less experience in inquiry commonly expressed research exposure in terms of *research-led* and *research-tutored* course-based activities, often exclusively described within the context of an undergraduate statistics or research methodology course. Inquiry was seen largely as a means to research, rather than a separate entity, as one student noted, “Inquiry is about how to create a good research question, and then how to carry it out would be the research aspect” (undergraduate student, geography, year 3). Undergraduate research opportunities were seen to create the structured environment for this level of inquiry learning.

Other students struggled with defining inquiry altogether, largely owing to a lack of personal experience: “I’ve never heard of it . . . I’ve heard that people have courses like that, but I’ve never had anyone approach me to say we have this in sociology” (undergraduate student, sociology, year 2).

For both students and faculty, undergraduate research and inquiry was considered most effective when it involved “empowering the student” (faculty member, English) and was “supervised by professors” (undergraduate student, geography, year 3) through mentorship.

(2) Structure and delivery

In these faculties and departments, inquiry was not *scaffolded*—or systematically embedded—into curricula. Rather, it appeared to *bookend* the program of study, often appearing as a stand-alone

course in year one, and reintroduced in year four. In this model, there was limited to no availability of inquiry-style teaching (for example, structured-, open-, or guided-inquiry) in years two and three. Instead, students were expected to apply the research skills and methodologies acquired during early undergraduate studies in their final year during a thesis, project course, or “internship work” (faculty member, communications): “The long-term vision is to have an inquiry approach to learning bookend the program, so that [students] get it in first year, and then in their fourth year, as they’re transitioning to wherever they’re going next” (faculty member, social sciences).

When probed, this faculty member expanded further: “The first year is about exploration, the second and the third year is more of a foundation, and then the fourth year is an application” (faculty member, social sciences). This suggests that the *bookend* model reflects the idea that an undergraduate curriculum should follow a logical pedagogical progression. Faculty attributed this *bookend* approach to the ideology that “second and third year is more discipline-focused rather than student-focused” (faculty member, social sciences). When inquiry re-emerged in upper years, it was expected that students re-engaged in learning with the confidence and competence to apply skills in undergraduate research and inquiry. For example, “Humanities is strong in first year and then strong in fourth year because of the independent courses, which are offered as a kind of capping experience” (faculty member, English).

(3) Barriers and limitations to opportunities

Faculty of *bookend* modeled programs identified limited resources, especially funding, as a “key piece and oftentimes, a stumbling piece” (faculty member, geography) restricting their ability to scale up inquiry and research opportunities to achieve a student-centered approach to learning. In larger classroom settings, which prohibited one-on-one facilitation, lectures/didactic inquiry teaching were described as common teaching methods: “I’d lecture for a week on ‘how to find a question.’ How to generate the research that comes out of your question, that would be another lecture. It’s all inquiry in those lectures” (faculty member, English).

These changes arose due to issues of sustainability of undergraduate research and inquiry, as this faculty member described: “We had some money back in the early days to have smaller Inquiry classrooms with a lot of different faculty. That money eventually ran out and we were going to have to find a way of teaching Inquiry in a larger classroom if we were going to be able to continue” (faculty member, English).

From the student perspective, the barriers to undergraduate research and inquiry engagement revolved around lack of awareness, lack of access, and lack of perceived impact, with lack of awareness as the largest barrier to undergraduate research and inquiry opportunities. When opportunities *were* available, these students felt that the experiences were not easily accessible and generally limited to in-class announcements and word of mouth: “I think it’d be cool to have the opportunity to do more research, but McMaster doesn’t do a good job of making those things accessible to students” (undergraduate student, political sciences, year 2).

Students also acknowledged that attaining “high grades” as “the best thing that you can do to gain access and early entry into these research opportunities” (undergraduate students, geography, year 3).

Opportunities for undergraduate research and inquiry appeared akin to applying for a job, and employing the same strategies (such as submission of a CV, strong academics, expressed interest, prior

experience, and an interview) for success, as illustrated by another undergraduate student: “I recognized that opportunity, so I sent him my statement of interest and CV” (geography, year 3).

Finally, students recognized the competitive nature of gaining access at an early stage of development and cited the risks of not making meaningful contributions, or disinterest by one’s supervisor in their growth and development: “For one of my experiences, I spent two years in a lab. For my first year and a half, my professor had been assigning me to do grunt work data analyses or other things. I didn’t really get my own project. When I did end up getting my own project, it just didn’t work out. We didn’t get results . . . and [my supervisor] wasn’t too encouraging of me presenting it at conferences” (undergraduate student, biology, year 4).

(4) Value

These students described inquiry learning as an asset to developing transferable skills, whereby theoretical knowledge could be transferred and applied beyond their university studies: “You’re taking that theoretical knowledge that you learn in university and then applying it to real life experiences . . . to what you are truly interested in” (undergraduate student, communications, year 3). Another student said, “Applying what you learn in lecture to solve a problem, or simulate what you would be doing in a future career” (undergraduate student, geography, year 3).

As students learned “how to be more critical and improve analytical skills” (sociology, year 4), the critical thinking skills gained were seen as applicable to a variety of disciplines: “You can go into law, politics, and business with an English, history, or philosophy degree because you’re trained to be a critical thinker” (faculty member, English).

Abstract model

(1) Perceptions

Finally, there appeared to exist a small subset of programs that do not employ inquiry-style learning, resulting in definitions of research and inquiry that were outcome-oriented, rather than student-oriented: “I would say it [inquiry] does work together in the sense that based on the research question at hand, you essentially come up with the proper investigation technique. I’m using inquiry and investigation interchangeably here, but basically the idea is that based on whatever I need to find out, I’m essentially going to devise a strategy or a methodology” (faculty member, business).

These faculty members described research as equivalent to innovation, and one that must have direct real-world applicability: “extracting meaningful insights” (faculty member, business). In contrast to the prior models, they viewed inquiry as learning *independent* of uniqueness: “Gain an understanding of a situation or a problem, whether or not other people already understand the problem” (faculty member, software engineering). Thus, the two concepts were not readily amalgamated, and when probed, a definition of undergraduate research and inquiry could not be provided.

(2) Structure and delivery

Research is conducted on a case-by-case basis in these programs. There are no policies to support or guide this process, and the manner in which student research is conducted, if it is conducted, is left entirely to the discretion of individual faculty members: “Undergraduate research is done according to the faculty members with whom the undergraduates work. The faculty member establishes how they want the research to be conducted” (faculty member, software engineering).

Unfortunately, we had no student participants from these programs to provide perspective.

(3) *Barriers and limitations to delivery*

Our participants from this model had difficulty providing an understanding of inquiry and undergraduate research and inquiry, and acknowledged that “we do not have . . . that culture of student” (faculty member, business). This speaker went on to describe the absence of motivation among their students to pursue undergraduate research and inquiry, and felt that without this “culture,” increasing access remained a barrier.

Numerous other barriers were also identified. First, the current student-to-faculty ratio is not favorable for involving students in undergraduate research and inquiry, and any opportunities are heavily faculty-dependent. The select few faculty members who do wish to take on students are limited by lack of funding and resources: “If there’s more funding, there would be more access. I think that’s safe to say . . . Right now, we have too many undergraduate students to make that possible (faculty member, software engineering).

Second, finding the time to commit to student learning was seen as an added pressure for many faculty members new to, and even those familiar with, undergraduate research and inquiry. The effect of faculty buy-in became evident when they had to weigh certain factors in assessing the value of whether to commit to training students. As one faculty member explained, they see little merit in taking on students who “do not have enough experience to contribute in a significant way to research projects,” which results in students being “more work than help” (faculty member, software engineering).

Whereas *scaffold* and *bookend* modeled programs actively seek to onboard faculty familiar with undergraduate research and inquiry, and train those who are not, programs that hold undergraduate research and inquiry as solely an *abstract* concept demonstrate no such incentive. Rather, in this model, there seemed to exist a mindset that undergraduate students do not have much to contribute to the projects of supervisors: “Undergraduates, especially in computing, are not mature enough to come up with reasonable research problems . . . I think the key thing is that you’re dealing with undergraduates who are inexperienced compared to other researchers” (faculty member, software engineering).

Furthering this thought, another faculty member discussed the lack of time for students to learn the necessary research skills as a barrier: “For us, because we are mostly more of a mathematical area . . . unfortunately, given the depth of understanding requirement where you can really start using these techniques and tools to investigate a topic, we don’t have enough room at the undergrad level to cover this” (faculty member, management sciences).

(4) *Value*

One faculty member commented on the utility of a students’ unique skill set as a means of providing labour predominantly for other departments: “There are research opportunities for our students across the whole university . . . They tend to have strong computing skills, and these skills are needed in research projects everywhere. Many of our students, as undergraduates, do more research outside of our department than they do inside” (faculty member, software engineering).

No intrinsic student values, nor applicability post-graduation, could be identified.

DISCUSSION

The literature suggests that universities have adopted inquiry and research curricula since the release of the 1998 Boyer Commission Report, yet our findings suggest that practices to improve student access to inquiry-based learning or undergraduate research have not diffused equally across the university.

Our findings showed that the dispersion of undergraduate research and inquiry curricula could be mapped along a spectrum—at one end, departments unknown to employ undergraduate research and inquiry; in the middle, departments seeding a culture of encapsulating the student experience with inquiry-based learning; and at the other end, departments where undergraduate research and inquiry philosophies are integrated into the curriculum and offer more opportunities for greater access to these experiences.

We termed these two models of implementation the *scaffold* model and the *bookend* model. The idea of a *scaffold* curricular design emerged in the inquiry literature more than 30 years ago (Vygotsky 1978). This model refers to the process of “controlling those elements of the task that are initially beyond the learner’s capacity, thus permitting him to concentrate upon and complete only those elements that are within his range of competence” (Wood, Bruner, and Ross 1976, 90; Simons and Klein 2007). In a *scaffold* model, inquiry is not an adjunct, but rather the *fulcrum*, to the learning process. At our institution, these programs typically, although not ubiquitously, accept smaller cohorts of students, with curricula and research opportunities driven largely by students (in comparison to *bookend* and *abstract* models, which prefer to utilize students to further faculty-driven research). In fact, we termed the *abstract* model as such to highlight those departments that view undergraduate research and inquiry as purely an *abstraction*—something in theory—rather than an educational tool to be used in practice. As the level of *scaffolding* decreases, the independence of the student should increase. Thus, a progression exists in the “level of student autonomy” as one moves from “structured to guided to open inquiry” (Spronken-Smith and Walker 2010, 735).

Programs new to undergraduate research and inquiry, but in favor of its implementation, identified poor awareness and access, lack of faculty buy-in, and the resource-intensive nature of the approach as barriers to its implementation and growth. For such programs, under the *bookend* model, early introduction to inquiry courses has proven necessary in order to better equip undergraduate students for the intellectual rigour required to excel in their final year thesis or project courses. Unfortunately, as cohort sizes become too large, delivering student-centered undergraduate research and inquiry becomes unsustainable, and faculty and departments (as our faculty member from the Department of English described) must alter whether and how they choose to deliver undergraduate research and inquiry material (as discussed below).

Finally, programs unfamiliar with undergraduate research and inquiry viewed inquiry as resource-exhaustive without assurance of student learning. The needs of the faculty seem to drive the opportunities for student research involvement, and these programs overall lack the culture to support inquiry both within and beyond the curricula delivered.

From the student perspective, data showed a clear divide between undergraduate students who had a firm grasp of inquiry and research, and those who were less familiar with or had less exposure to undergraduate research and inquiry. Departments that embedded undergraduate research and inquiry philosophies into their programs have historically integrated project courses and research opportunities as a core component of their curricula—continually augmenting opportunities for improvement and

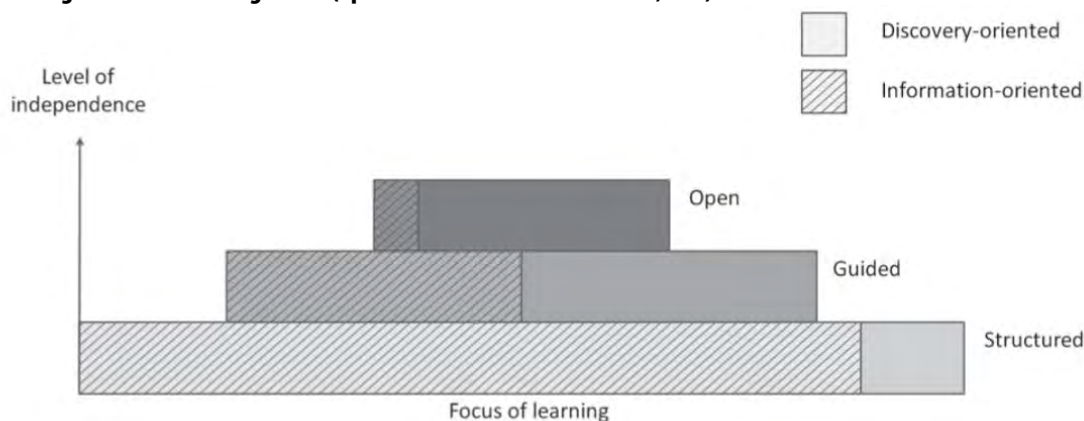
access for students. Our results illustrate that departments with steadfast cultures of undergraduate research and inquiry were similar in nature to the teaching-research nexus that forms a “community of practice” of research (Spronken-Smith and Walker 2010, 728), and student participants were keenly aware of the pedagogical privilege afforded them through undergraduate research and inquiry experiences.

Toward building capacity for undergraduate research and inquiry

How undergraduate research and inquiry is defined can have an impact on the manner in which it is implemented (Beckman and Hensel 2009). In our study, perhaps the most striking difference between the way students and faculty perceived undergraduate research and inquiry was with respect to the relationship between *research* and *inquiry*. We, as have others, found that across institutions and between the disciplines, there appears to be immense variability in what is considered undergraduate research and inquiry (Aditomo et al. 2013, 1246–49).

Spronken-Smith and Walker (2010) sought to conceptualize the research-teaching nexus by constructing a stepwise model that links the level of student independence and the strength of the teaching-research nexus (see figure 2).

Figure 2. The relationship between focus of learning, level of independence (or conversely *scaffolding*), and the potential for a strong research-teaching nexus (Spronken-Smith & Walker 2010, 736)



Note: The strength of the teaching-research nexus correlates with the level of shading.

Faculty participants working in strong cultures of undergraduate research and inquiry were able to conceive of the two concepts as a single entity, whereas other faculty participants working in departments less familiar with the approach most often described research and inquiry as achieving *separate* goals. This debate prolific in the literature views *research* as the expansion of personal knowledge, but primarily views it as the investigation of unanswered questions and incorporation of something new to an area of study (Buckley 2011; Levy and Petrulis 2012). Unique to the nature of undergraduate research and inquiry, questions remain: Should the focus of learning be on *existing* knowledge, or does it necessitate constructing *new* knowledge (see also Spronken-Smith and Walker 2010)? That is, can undergraduate students make meaningful contributions to the discipline in their role as learners, thus justifying the allocation of time and resources toward inquiry-based activities?

In looking at programs foreign to undergraduate research and inquiry, it became readily apparent to us that undergraduate students—at their current stage of education—are viewed simply as lacking the experience and education to contribute meaningfully to departmental research. In cases where these faculty described “inquiry”-based learning, it was described as learning *independent of uniqueness*, and primarily serving only the interests of the learner. We note that seeds of this mindset appeared in *bookend* programs, but certainly not to the same extent.

When participants from *scaffold* modeled programs discussed undergraduate research and inquiry, they perceived that knowledge discovery coincided with scholarly growth, with curricula in this approach serving as the foundation for learning. We have found that the philosophy of undergraduate research and inquiry as experiential-based learning has the research *process* and *progress* co-occurring in order to maximize student scholarly contribution. Learning *through* the research process is one of four main approaches to inquiry-based teaching (Turner, Wuetherick, and Healey 2008, 200; see also Healey 2005, 70). In such settings, the student-faculty relationship promotes the undertaking of research endeavors from which novel contributions to the discipline emerge *by way of* student growth. Our study also found that programs employing a *scaffold* model reported more control over the agenda for undergraduate research and inquiry, and identified funding and resources as the main barriers to expanding their firmly established cultures.

In contrast, in a *bookend* model, inquiry-based learning appeared to encapsulate the undergraduate student experience in years one and four without sustained integration, and served primarily as a complementary component to the students’ education. Early introduction to guided inquiry culminating with a *capstone*, open-inquiry project—a concept theorized by Spronken-Smith and Walker (2010)—is a method of building and maintaining student motivation to learn. Students remarked that introducing inquiry courses in the first year was initially somewhat of a *culture shock*, but ultimately acknowledged it better equipped them for the intellectual rigour required to excel in their final year thesis or project courses.

In both the *scaffold* and *bookend* models, however, it was understood that the research process supports learning through the *medium* of inquiry, so that students will eventually develop research knowledge as well as research output.

Several of our university’s departments currently function in this way—encapsulating, rather than integrating, their students’ undergraduate experience with inquiry-based learning— supporting the applicability of the *bookend* model. These programs found themselves in the process of constructing a culture of undergraduate research and inquiry, while at the same time lacking funding, departmental support, and faculty buy-in for building more capacity. While significant progress had been made in these departments, these *bookend* programs remained quite vulnerable to financial constraints that dictated the delivery of education. Faculty participants provided numerous examples of having to sacrifice student research and inquiry experiences for large-scale, teacher-focused, didactic learning. That is, despite the well-recognized benefits of curricula built on undergraduate research and inquiry, it proved to be unsustainable for the larger student body, and instructors were forced to abandon their efforts. While the onus to incorporate inquiry-based pedagogy falls on individual course instructors—especially in departments within didactic, non-experiential settings—*structured* or *guided* forms of inquiry in place of “open inquiry” were considered preferential when faced with large class sizes (Spronken-Smith and Walker 2010, 737).

Toward improving access for students

Without a centralized and organized process at the departmental level, a hierarchical boundary remains between the student and faculty supervisors: the faculty are *gatekeepers* to the research experience. Mentorship, above all, dictates the undergraduate student experience, with minimally guided instruction of project- and inquiry-based learning resulting in ineffective teaching (Kirschner, Sweller, and Clark 2006). Enterprising students at our institution have adapted to and learned the vetting process to access research, and they make strategic efforts to acquire faculty connections to increase their chances and opportunities to be involved in research and inquiry. However, the majority of students reported that access to opportunities remained largely happenstance. A clear divide emerged between those who had a firm grasp of inquiry and the research process—because they experienced such programs—and those who had limited to no opportunities to understand or experience research and inquiry. The trend of certain departments (such as science, social sciences, and humanities) to actively seek to involve their students in research and inquiry more than others (such as business, economics, engineering, and technology) revealed itself in our study (see also Lee, Myatt, and Joughin 2012). Nonetheless, the goal of undergraduate research and inquiry—as emphasized by Christopher Justice, James Rice, Wayne Warry, Sue Inglis, Stefania Miller, and Sheila Sammon (2007)—remains to create the environment necessary for students to succeed. Thus, it was reassuring to hear our student participants speak highly of the transferable life skills they developed uniquely through exposure to research and inquiry.

If curriculum drives education delivery, then culture drives student learning. Torgny Roxå and Katarina Mårtensson (2015) emphasize the importance of academic developers' understanding the departmental policies, *microcultures*, and what Megan Anakin, Rachel Spronken-Smith, Mick Healey, and Susan Vajoczki (2018, 7) call “territory force,” which ultimately dictate curricular change. Our faculty participants provided a further perspective whereby apprehension and skepticism become almost instinctual responses when one is pressured to teach curricula in a manner that is costly, unknown, resource-intensive, and non-content driven. In *teacher-centered pedagogy*, which has historically served as the standard for educational delivery, the use of lecture is the primary means of communication as “the goal of the classroom involves the dissemination of a relatively fixed body of knowledge that is determined by the teacher” (Mascolo 2009, 4). This has served as a familiar, conventional form of content delivery, especially when facing large class sizes, to the extent of becoming ingrained into the culture and norms of the institution. As reflected by the literature of the last decade, the goal of inquiry-based education is to centralize the student as both *learner* and *contributor*. Steadfast in their current ways are those departments new or skeptical to inquiry, and moving between culture and curricula remains a challenge. While funding challenges and limited resources persist, individual faculty buy-in and comfort with teaching inquiry has repeatedly proven to be a critical determinant of success.

Indeed, there appeared to be a bidirectionality to undergraduate research and inquiry, with its merits evident for both students and staff. This is best demonstrated with the recent growth and interest in what is termed “students as partners” (Cook-Sather, Bovill, and Felten 2014; Marquis, Black, and Healey 2017). As Donald argues, this capacity for inquiry does not appear department-specific, and there seem to exist within inquiry-learning thinking processes—description, selection, representation, inference, synthesis, and verification—common to a wide variety of university disciplines (Donald 2002, 26). While the literature describes varying interpretations of both undergraduate research and inquiry,

there is virtual unanimity that this model of learning maximizes the student experience (see Healey and Jenkins 2018).

Furthermore, an intriguing concept seemed to emerge with the students of both *bookend* and *scaffold* model programs, wherein they were accessing opportunities for undergraduate teaching and learning of their own accord. The models we describe embed research and inquiry within departments to varying degrees, yet several enterprising student participants discussed their involvement in research opportunities. In this *independent co-curricular* fashion, students in programs with a culture of undergraduate research and inquiry described gaining advantageous opportunities for self-directed learning and career advancement. This access to student research may prove critical for departments that describe an inability to sustain thinking processes due to growing class sizes and limited resources. Unfortunately, the limited data available to us precludes the inclusion of *independent co-curricular* within our schema, and future research with undergraduate student participants across a variety of disciplines probing specifically into self-acquired opportunities for research and inquiry beyond the formal curriculum would certainly be of interest. As it currently stands, however, there is not likely to be equitable access, because those students pursuing the co-curricular opportunities for research and inquiry have both the curriculum flexibility and ambition to pursue them.

In all, the need for clarifying undergraduate research and inquiry conceptually led us to the discovery that there are few differences between them. In their seminal report, Healey and Jenkins (2009, 79–92) argue that undergraduate students in all higher education institutions should be learning through, and about, research and inquiry. They outline the *nature* of undergraduate research and inquiry as comprising research-tutored, research-based, research-led, and research-oriented undergraduate learning experiences (see figure 1). Similar to the observations made by Healey and Jenkins (2018), we found at McMaster University that intra-institutional practices and policies differed substantially across departments and faculties. We examined a wide range of departments across the institution and concluded what has been hypothesized for the past decade further reinforces the role of undergraduate research and inquiry in university education of the twenty-first century. Furthermore, our findings demonstrate that over time, with sustained student participation and continual emphasis on research processes and problems, an institution can create for itself a *culture* of undergraduate research and inquiry—one in which the teaching philosophies of this approach are reflected in program curricula, recognized and appreciated by faculty members and students, and reinforced by practices aimed at promoting such opportunities.

LIMITATIONS

One limitation of this study is the relatively small number of undergraduate participants. Furthermore, students with prior inquiry or research experiences may have self-selected to share their experiences. However, the range of experiences described and disciplines represented among the students provides some reassurance that we sampled broadly. In addition, as a relatively small number of faculty were interviewed, we can make no claims about the degree to which their impressions and beliefs might be shared by their entire respective departments. Furthermore, our study was conducted at a single institution, which may limit the transferability of our findings to universities with varying cultures or curricula. However, as our aim was to provide a model of diverse philosophies about and practices of undergraduate research and inquiry, we believe that institutions with both similar and divergent approaches to teaching and research will find value in our work.

CONCLUSION

Although we cannot conclude that simply conceptualizing undergraduate research and inquiry foreshadows its implementation, our findings do suggest that the teaching and learning nexus of research and inquiry is stronger in places where inquiry-based learning is a long-standing aspect of teaching practice and student experience. Although we explored one institution-specific conceptualization of undergraduate research and inquiry, we believe that for higher education as a whole, outlining the various approaches to pedagogy built around undergraduate research and inquiry is critical to mapping its progression from unknown concept to emerging practice and competent execution.

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Andrew Perrella is an internal medicine resident physician in Hamilton, Ontario (CAN).

Huyen Dam is a doctoral candidate in the School of Geography and Earth Sciences at McMaster University (CAN).

Lynn Martin is a teaching professor in the School of Nursing at McMaster University (CAN).

John C. MacLachlan is the director of the Intersession Program at McMaster University (CAN) and industry professor in the university's School of Geography and Earth Sciences.

Nancy Fenton is associate director of research at the Paul R. MacPherson Institute for Leadership, Innovation & Excellence in Teaching at McMaster University (CAN).

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APPENDIX A: FACULTY INTERVIEW GUIDE

Themes	Question	Probes/Prompts
Conceptualization: Definition of undergraduate research and inquiry	1. In your own words, how would you define URI?	
	2. What characteristics do you think are most important in defining URI?	
	3. Are there policy and/or key documents at the university or within your department that you draw URI principles from?	
Operationalization: How URI is implemented	4. What drives URI in your faculty?	Value? Funding?
	5. What types of URI activities are available to students in your departments/programs?	Co-ops? Internships? Undergraduate Student Research Awards? Curriculum base?
	6. Do you know of other types of URI activities that exist outside of your department that provide opportunities for students?	
	7. At what level is URI available to students?	Year 1, 2, 3, 4? All of the above?
	8. Are URI opportunities available to all students?	Some? How are these students selected? Types?
	9. Do students in your program value the experience of URI learning?	How do you know? Is it evaluated?
	10. What are the benefits of URI to students in your program?	
	11. Can you name 3-5 faculty and/or administrative members who you think best implement URI in their curriculum?	

Challenges of implementing URI	12. Are there barriers to providing URI opportunities for students?	Examples?
	13. Are there ways to increase student access to URI opportunities?	
	14. Are there administrative barriers to implementing URI?	Examples?
Closure	15. Is there anything else about URI that you think is important for us to know?	

Note: URI – undergraduate research and inquiry

APPENDIX B: STUDENT INTERVIEW GUIDE

Themes	Question	Probes/Prompts
Student perception of URI	1. What does undergraduate research and inquiry mean to you?	
	2. In your own words, how would you define URI?	
Student experience of URI	3. Have you had any URI experiences while studying at McMaster? If yes, probe types.	3a. Types: Co-op? Internships? Curriculum? 3b. When? 1st, 2nd, 3rd, 4th year?
	4. Was there a selection process for accessing URI opportunities?	
	5. What did you gain from your URI experience?	
	6. Were there things you had hoped to gain but did not?	
	7. Were there barriers to you accessing URI or barriers that limited your experiences of URI?	
	8. What suggestions can you offer to improve URI opportunities to students?	
Closure	9. Is there anything else about URI that you think is important for us to know?	

Note: URI – undergraduate research and inquiry



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