UNIVERSITY OF CALGARY

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A Guide for Undergraduate Research at UCalgary

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TAYLOR INSTITUTE FOR TEACHING AND LEARNING | UNIVERSITY OF CALGARY

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Introduction

Undergraduate research activities are meaningful Experiential Learning (EL) opportunities where students "learn by doing" and develop research and transferable skills. High-quality research experiences intentionally evoke students' curiosity, engage students in the discovery process, ensure opportunities to disseminate findings, and extend learning through critical reflection. With thoughtful design and mentorship, undergraduate research immerses students deeply in a topic while encouraging students to take risks, develop as people and professionals, and build resiliency by overcoming inevitable challenges that arise in research. Research is a meaningful way to engage students as partners in inquiry, inviting them to become creators and contributors of discovery and knowledge.

For more than three decades, post-secondary institutions in Canada have sought to innovate and enhance education by providing research opportunities for undergraduate students. In particular, research-intensive academies such as the University of Calgary have been well-positioned to engage students in producing and disseminating original knowledge, scholarship, innovation, and creative endeavours. Since the Boyer Commission (1998) published its influential blueprint on *Educating Undergraduates in the Research University*, the purpose and means to educate using research have been clearly articulated. Namely, the rationale calls for undergraduate instruction to emanate from a "deep and abiding understanding of the inquiry, investigation and discovery at the heart of the enterprise" (p. 18). Highlights include offering:

- Inquiry-based first-year experiences
- Interdisciplinarity, disciplinary breadth, and a diversity of research experiences
- Mentorship and apprentice instruction from graduate students
- Access to first-class research infrastructure (Information Technology, libraries, labs, art galleries and concert halls)
- Research-based teaching and learning with research synergies

- Integrative curriculum (communication skills and writing intensity)
- Capstone and culminating experiences

More recently, faculty, staff, and leaders working in Canadian higher education have substantiated high-quality undergraduate research opportunities by establishing and supporting dedicated offices, initiatives, and scholars. These demonstrable efforts have embedded undergraduate research into teaching and learning practice and scholarship, institutional strategic plans, purposeful communications, and evaluation metrics. Exemplars include the University of Alberta's Undergraduate Research Initiative, McMaster University's Students as Partners program, the University of Saskatchewan's First-Year Research Experience Program, and the University of British Columbia's Carl Weiman Institute.

Drawing inspiration from these and other examples, the College of Discovery, Creativity, and Innovation (CDCI) at UCalgary has engaged in a consultative process with the campus community regarding undergraduate research and, in 2020, launched the Undergraduate Research Initiative (URI). The URI seeks to advance undergraduate research across campus by providing multiple entry points for students to access research opportunities. Undergraduate research greatly contributes to the UCalgary **Academic** and **Research** Plans by enhancing student experience and impact, driving innovation through teaching and research integration, increasing research capacity, and connecting communities. As part of the integrated model of the Academic and Research Plans, the URI aims to Facilitate Interdisciplinarity (Priority 3.1) through interdisciplinary teaching, research, and learning and promote institutional frameworks for developing interdisciplinary curricula and curriculum design. The CDCI also takes directive from the Academic Plan to "refine and scale up the offerings of the College of Discovery, Creativity and Innovation (CDCI)" and "explore additional opportunities for course credits for undergraduate research experience" (Priority 3.4).

In all undergraduate research experiences supported by the CDCI, students learn about research by doing research. This "learning by doing" is captured as one of the categories of Experiential Learning defined in the **Experiential Learning Plan (2020-25)**, Research-Based Experiential Learning, where students lead or contribute to a research project. The Experiential Learning Plan establishes a target of all undergraduate students participating in at least two Experiential Learning opportunities. The work of the CDCI supports the Experiential Learning Plan by expanding capacity, reducing barriers, and increasing opportunities for students to participate in research.

As a result, the CDCI has developed a vision and goals for undergraduate research to align with the **Academic Plan**, **Research Plan**, and **EL Framework**. In alignment with institutional strategies, we believe students "thrive in programs made rich by research, and hands-on experiences" (UCalgary Experiential Learning Plan 2020-2025). Undergraduate research is at the center of a university's purpose "to contribute to the body of world knowledge while simultaneously engaging our students in learning guided by processes of discovery, creativity, and innovation" (**Eyes High Strategy**).

How to use this guide

Our intended audience for this guide is instructors designing curricular undergraduate research experiences or research mentors supporting undergraduate research experiences in an apprenticeship model during curricular or non-curricular undergraduate research experiences. We have written this guide with an awareness of the disciplinary differences in research and student diversity while still providing meaningful guidance and direction for the research process. We hope you will use this guide to design research-based courses or develop support for one-on-one mentorship of research experiences. We may use the terms "instructors" and "research mentors" interchangeably throughout or use one title or the other to signal curricular or non-curricular research experiences. Graduate Teaching Assistants supporting undergraduates conducting research will

also find value in this guide. Finally, undergraduate students undertaking a research project may also find this guide beneficial in understanding the research process and designing their investigation.

We wrote this guide with the intention that it would be read from start to finish. However, each of the three sections could be read and implemented independently and interchangeably:

- **Section I: Undergraduate research experiences**
- **Section II: Design of undergraduate research experiences**
- **Section III: Mentorship of undergraduate research experiences**

Goals of the guide

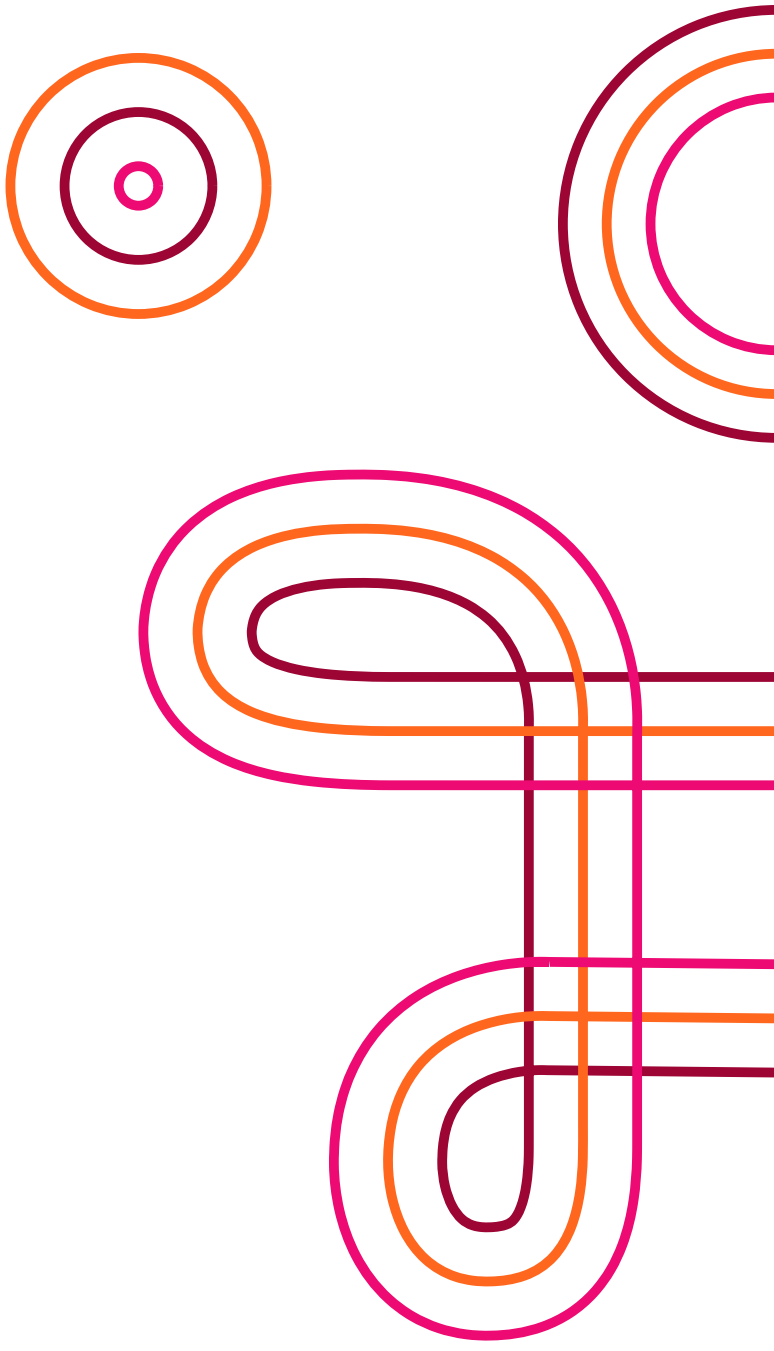
Often when faculty consider undergraduate research, they envision an independent studies course or a year-long honours project where a student works one-on-one with a faculty supervisor. This apprenticeship model remains a valuable undergraduate research experience. However, this guide highlights the diversity of experiences comprising undergraduate research, scholarship and creative activities and inspires faculty to incorporate more widely into teaching and mentoring practices.

We hope to support instructors and researchers in the design and mentorship of undergraduate research in many contexts. We offer this resource to:

1. Describe key components of meaningful research, scholarly, and creative experiences at the undergraduate level.
2. Outline and examine the benefits of undergraduate research to students, faculty, staff, graduate students, and institutions.
3. Highlight a diversity of approaches for designing undergraduate research, scholarship, and creative activities to develop students' skills.
4. Provide resources and support to enable faculty members, staff, and administrators to plan, design, implement and assess research experiences.
5. Provide recommendations and resources for mentoring undergraduate research.

"I appreciate [undergraduate research] because it enables student agency, curiosity, and authentic assessment. Students take responsibility for their learning. They discover, synthesize, and integrate the best research available into practical resources. They have an opportunity to be bold and creative."

- Course-Based Undergraduate Research Instructor



Section I: Undergraduate research experiences

What is undergraduate research?

According to the **Council on Undergraduate Research**, "Undergraduate research is a mentored investigation or creative inquiry conducted by undergraduates that seeks to make a scholarly or artistic contribution to knowledge."

Let us examine this definition for a moment. This definition reflects that research activities are highly diverse across disciplines, employing different methodologies, frameworks, and constructs. The inclusions of **"investigation or creative inquiry"** and **"scholarly or artistic"** broadens the conceptualization of undergraduate research to encompass disciplinary diversity, transdisciplinarity, and centers creative and artistic activities in the context of undergraduate research (Brew & Boud 1995; Judge et al. ,2019; Palmer et al., 2015).

The next portion of the definition focuses on the outcome of the investigation or creative inquiry. The Council on Undergraduate Research definition describes the outcome of undergraduate research as **"seek[ing] to make a [...] contribution to knowledge."** We appreciate the term "seeks" here as it highlights the intrinsic value of undergraduate research irrespective of external definitions of new knowledge. This definition allows room to recognize the skill development and training that can occur while seeking to contribute to new knowledge. To move away from valuing only novel contributions to the discipline, Brew and Boud (1995) provide a framework for considering undergraduate research as an investigation by students into the:

- **Commonly known:** known by faculty in a discipline, but new to the student
- **Commonly unknown:** known only by a few specialists in a field, but unknown to the student and faculty outside of that specialty
- **Totally unknown:** unknown to everyone, which makes an original contribution to the field

We believe that even if undergraduate research does not stretch into the totally unknown, there is immense value to the students rediscovering what is previously known and learning to engage in the research process.

In Section I, with this definition in mind and recognizing that research activities and students engaging in research are highly diverse, we provide

a framework for high-quality undergraduate research experiences. Despite the incredible diversity in research, there are often commonalities to the process. Researchers typically engage in the following (Kinkead, 2003; Lopatto, 2003; Healey and Jenkins, 2009):

1. Identify an interest, passion, point of curiosity
2. Explore the available knowledge, data, materials, and theoretical landscape
3. Formulate a research question, the study aims or objectives and, in some contexts, hypotheses
4. Identify the knowledge required to meet research aims (existing and gaps)
5. Identify and generate information or data required using appropriate methodology
6. Evaluate the credibility of sources, information or data and make the research process visible
7. Organize or reconfigure information or data or materials to reveal patterns or themes
8. Analyze information or data critically and synthesize to produce a coherent understanding or introduce new knowledge to express a creative vision
9. Communicate research findings or creative endeavours to a specified audience

This list represents a sequential movement through the research process; however, research is rarely a linear progression through these steps. It can involve jumping forwards, backwards, and revisiting steps as one goes. Providing undergraduate researchers with this high-level overview of the research process can help students see the entirety of the process and navigate from one step to the next.

Where can undergraduate research take place?

Research can take place in a variety of curricular and non-curricular settings.

Curricular	Non-Curricular
High and low enrollment courses from first to final year	Work-integrated learning opportunities such as internships and co-ops
Face-to-face and online courses	Community-engaged research projects
Independent study courses	Summer research assistant positions
Community-engaged learning and international experiences	Summer studentships, such as PURE awards
Honours theses	Part-time jobs and volunteer positions

What makes undergraduate research high-quality?

The quality of undergraduate research, scholarship, and creative activity can vary substantially. High-quality undergraduate research experiences adhere closely to the practices performed by researchers in the discipline (Eyler, 2018). Through investigation in the literature, developing the scholarship of undergraduate research, and our own experience, we have developed a framework for high-quality undergraduate research, including scholarship and creative activity.

We believe that a research experience becomes high-quality when it involves all these four elements: curiosity, discovery, dissemination, and reflection (Figure 1). These elements can help you design high-impact research experiences and also evaluate the quality of the research experience offered. In this section, you will find the theory supporting why each of these four elements is important for research experiences, how to put these ideas into practice with tools and examples, and reflective questions to help you start thinking about how to implement these ideas in the classroom or mentorship of students.

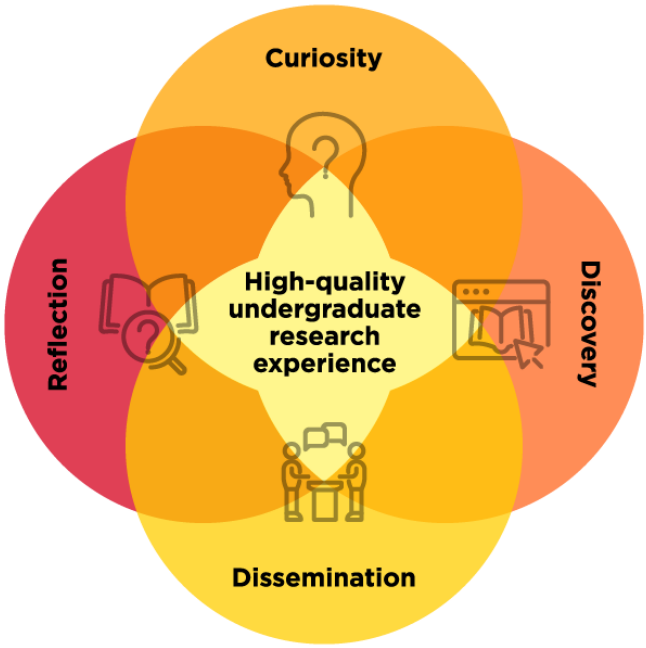


Figure 1: The Undergraduate Research Initiative Framework

Curiosity

THE THEORY

"At its core, curiosity is the desire for new knowledge, information, experiences, or stimulation to resolve gaps or experience the unknown." - Grossnickle (2016)

Curiosity, questioning, and the desire to deeply understand a phenomenon or problem should be at the heart of undergraduate research, scholarship, and creative activities. A high-quality research experience will encourage and celebrate students' creativity, fostering a habit in which students are driven and intrinsically rewarded to learn, experiment, and create. Their curiosity can take many forms, from researching a well-established topic to tackling a new problem about which little is known. Curiosity is important even if the topic is not new to the field but is new to the student. Aim to cultivate curiosity and encourage students to get excited about their research, scholarship, or creative activity as they engage with and develop the skill of curiosity.

"Research is formalized curiosity. It is poking and prying with a purpose." - Zora Neale Hurston

IN PRACTICE

There are many ways to encourage students' creativity. For example, consider how you model creativity in your interactions with students. Allow students the time to tinker with ideas and explore aspects of the topic for which they are interested during their research. Perhaps one of the simplest ways to engage curiosity is encouraging students to ask questions (Eyler, 2018).

Question Formulation Technique (QFT)

To develop students' ability to ask questions, try the Question Formulation Technique (QFT). This technique walks students through a series of steps to generate as many questions as possible on a topic (divergent thinking), identify criteria to evaluate and narrow down their questions (convergent thinking), reflect on their process (metacognition), and choose a single question to investigate or ask (commitment). This activity can be done individually or in small groups and can be used to develop a research question or encourage creativity about an existing area of inquiry.

If the research question for an investigation is student-driven, students will need guidance in taking their curiosity and developing it into a researchable question. Students may also need support in ensuring their research question is feasible, specific, novel, ethical, and relevant (Ratan et al., 2019). Having students refine their research questions using a Research Question Framework can help students develop a quality research question (Aslam & Emmanuel, 2010). See Appendix A for sample Research Question Frameworks.

In certain situations, such as in a large introductory class, when students have a semester or less to conduct their research, or when students join an already existing research project, some aspects of the research may already be established, or the research question may already be fully articulated. For example, a partnership with a community might already be established that determines the research direction and the research question itself. These situations do not need to limit students' creativity. In these cases, students need opportunities to engage creatively with the research topic. Be sure to provide students with the relevance of the problem (Govindan et al., 2020) and help them understand current knowledge in the field while establishing where the research project fits with the literature. Share your passion and enthusiasm for the research question and encourage student creativity regarding the question.

GETTING STARTED

To begin the process of stimulating your students' curiosity, jot down what comes to your mind when you ask yourself these questions in the context of your course or topic:

- What can I do to get students excited about research?
- How can I amplify the students' curiosity about a topic?
- How can I model curiosity in my day-to-day interactions with students?
- How can I encourage or give time for students to tinker, make observations, play with ideas, and read widely before asking their research question?
- How can I help students take their curiosity and frame it as a feasible research question to investigate?

Discovery

THE THEORY

In the discovery phase of research, students use modern, discipline-specific research methods to investigate a research question. In this phase, students learn genuine methods and techniques researchers in their discipline employ. With a well-designed research question and study, the investigation outcomes are **unknown** at the outset of the research project.

IN PRACTICE

- Work with students to complete the Research Planning Guide (Appendix B) to help them determine their research outcomes, activities and products. This planning guide will also help students produce a timeline with important project milestone markers.
- Consider developing clear guidelines and expectations for undergraduate researchers. In their 2015 article, Walden and Reyna discuss the elements used in integrating undergraduate research into their Laboratory for Rational Decision Making, which includes providing a manual at the start of the research terms,

outlining expectations like being on time and responding to emails, and taking the initiative.
- Check the University's Libraries and Cultural Resources for **Research Guides** and consult with your subject librarians.
- For lab-based experiences, rather than using a cookbook lab, where all the procedures are provided, have the students conduct a literature review to determine protocols (Govindan et al., 2020).
- If the research experience is curricular, outline what components of the research will be evaluated and by what standards.
- Schedule weekly research team or one-on-one meetings to ensure students progress and are supported.

GETTING STARTED

To begin the process of discovery, consider these questions in the context of your course or topic:

- How many hours per week will students have to conduct the research project?
- Is the scope of the project feasible?
- Is it a team or individual project? What aspects of the project are more appropriate for team vs individual work?
- What methodological training is needed to conduct the research?
- What safety training is required?
- Does the study require Animal Care Committee or Research Ethics Board approval or exemption (course-based approval or delegated approval)?
- Will other mentors need to be involved in the day-to-day activities of the students (TAs or graduate students in the research group), and what training or support will they require?
- What equipment or resources are required for the project?
- How can I help to ensure the project is moving along and successfully meeting project milestones?

Dissemination

THE THEORY

"Dissemination of results is an essential and integral part of the research process, which means that training in research cannot be considered complete without training in effective communication." - Boyer Commission (1998)

A critical aspect of research is disseminating the findings to a community. Dissemination should be a goal of undergraduate research as well. The aim should be to have your students' research seen beyond the eyes of the instructor or research supervisor. At the outset of the project, consider the level of exposure that will likely be appropriate for the research and the ways a student's research can be disseminated in addition to journal submission and conferences (Spronken-Smith et al., 2013).

Exposure	Modes of Dissemination
Course	Course poster session, journal club, course blog, research showcase, research group presentations, course podcast, pedagogical research contributions to course design
Departmental	Departmental poster session, mini undergraduate research student conference
Institutional	Campus-wide undergraduate research symposium, institution-based undergraduate research journals, open access repositories (see PRISM at UCalgary), interdepartmental collaborations
Local	Community partner project, local conference, local newspaper, local presentations, outreach events, local citizen science databases
National	National journals, national conference, federal databases, product launch, academic collaboration groups
International	International journals, international conferences, international databases, citizen science databases, social media, blogs

IN PRACTICE

When developing a collegial and productive learning environment, you hope to inspire well-prepared, confident students to do meaningful research. As an instructor or mentor guiding undergraduates through a research project, a positive end goal should be to disseminate their work in some form. This aspect of the research experience grows students' competence, confidence and collaborative skills and positions them well in their academic and professional careers. There are many levels of exposure, and you should discuss which of these are most appropriate with your students at the start of the research project and as it progresses. Often students need guidance in dissemination and communication skills.

In addition to the resources provided above, links to venues for students to consider disseminating their research are listed in the Additional Resources at the end of this Section. Encourage your students to read the information on these websites carefully and review past issues for examples of published work.

GETTING STARTED

At the outset of the project, ask yourself:

- What key stakeholders may be interested in the outcomes of this research?
- How can you reach your audience?
- What are creative ways to share the research findings?
- What level of exposure is appropriate for the research?
- To disseminate the work, will there need to be additional time and support invested beyond the students' research term?
- What agreements will you put in place regarding authorship and intellectual property to ensure the contributions of all parties are recognized?

Reflection

THE THEORY

"We do not learn from experience. We learn from reflecting on experience." - John Dewey (1910)

Reflection is the bridge between experience and learning. It involves making meaning of our experiences (Mezirow, 1980) and developing an understanding of how experiences translate into learning. Given that hands-on experiences are at the core of experiential learning and undergraduate research, supporting students by providing tools to facilitate making sense of experiences and articulating learning is essential (Ash & Clayton, 2009). Reflection and developing a reflective practice allows students to deepen the significance of their research experience, maximize and document learning, self-assess gaps, and set goals for growth (Ash & Clayton, 2009).

"When it is well designed, reflection promotes significant learning, including problem-solving skills, higher order reasoning, integrative thinking, goal clarification, openness to new ideas, ability to adopt new perspectives, and systemic thinking." - Ash & Clayton (2009)

IN PRACTICE

There are many ways reflection can be incorporated into a research practice. However, opportunities for reflection should be carefully and intentionally designed. Helping students develop a habit of evaluating what worked, what did not work, what they would do differently, and assessing what they learned, can support them moving past hurdles and keeping their research moving forward. Reflection can be informal in discussing reflective questions during a one-on-one meeting, or it can be a more formally structured written component used for assessment.

For students developing a reflective practice, the reasons why reflection is valuable need to be made explicit. You can help students see the benefits of reflection by acknowledging their learning and considering how it can be applied to new situations they will encounter. Additionally, students new to reflection often need a structure or framework to follow. Here we outline two commonly used reflective framework models.

What, so what, now what?

In this model, the reflective cycle begins with students describing the experience as the "**what**" of the reflection (Borton, 1970).

In the "**so what**" step, students begin to analyze the experience, explaining why the experience was important, what meaning they took from the experience, and what they learned.

In the final "**now what**" step, students explore how to take their new knowledge and skills, improve upon them, and apply them to new contexts.

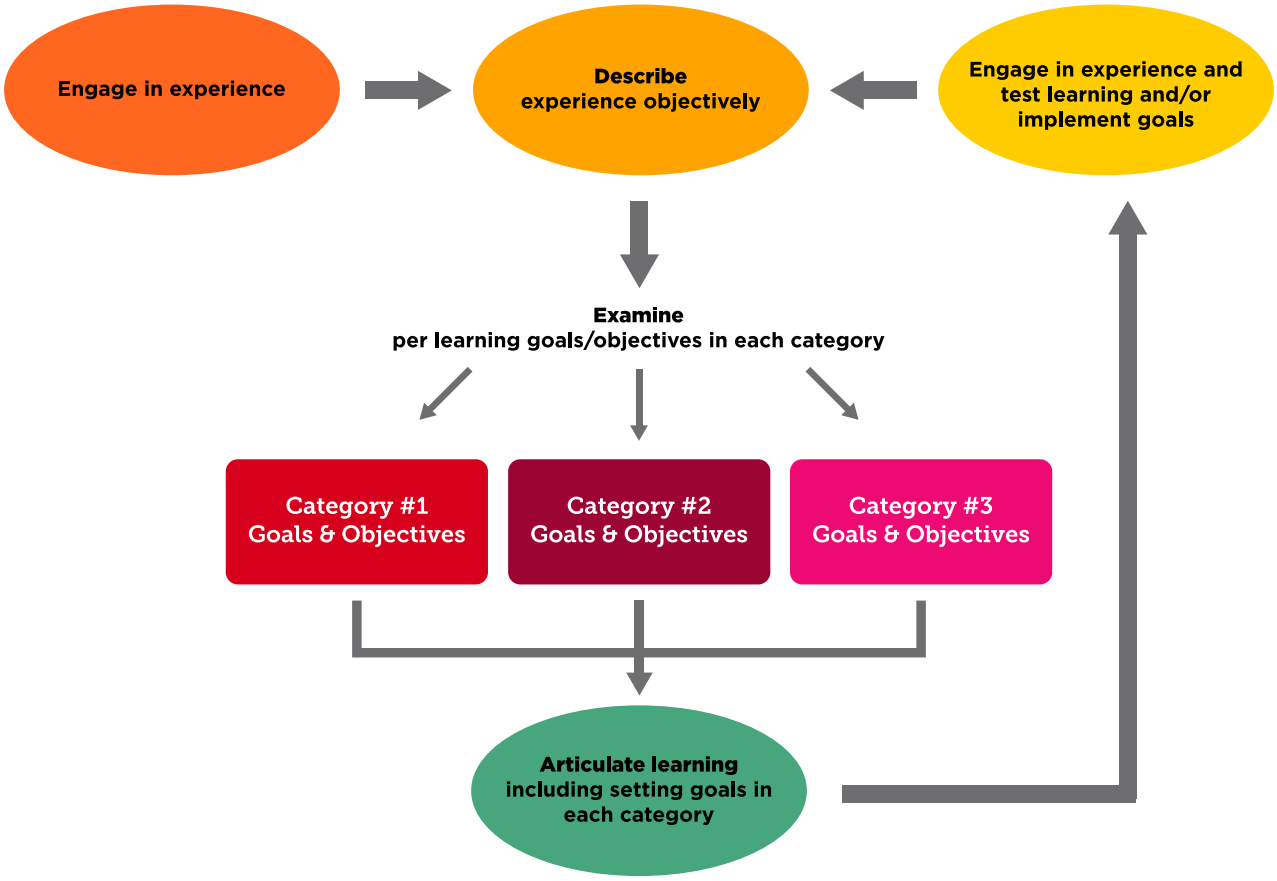
DEAL: Describe, Examine, Articulate Learning

In the DEAL model of reflection, students begin by first describing the experience, then examining the experience and finally articulating what they learned from the experience (Ash & Clayton, 2004, 2009).

Describe: Students begin a reflection by providing an overview of their experience, often focused on one to three key experiences. The description should be an objective account of the what, where, who, when, and why of the experience.

Examine: The students begin to consider the experience from academic learning, personal growth, or civic responsibility perspectives.

Articulate Learning: This is the final step and focus of the reflection. Students explore what they learned from the experience and why this is important to them academically, personally, or in terms of their civic responsibility. Students can also articulate what they might do differently in the future and set goals for learning.



Schematic Overview of the DEAL Model for Critical Reflection (Ash & Clayton, 2009).

GETTING STARTED

In the context of your teaching and research mentoring, consider the following:

- How can you help students reflect on their experiences?
- How can you model a reflective practice?
- For curricular research, can you incorporate reflective assessments into the curriculum?
- At what points during the research experience will you create a pause for reflection?

Benefits of undergraduate research

High-quality undergraduate research, scholarship and creative experiences are student-centered and aim to support student development. These experiences mainly benefit undergraduate students themselves, and this is where the focus of initiatives should lie. However, while these interactions are rarely fully reciprocal, there is also potential for benefits to faculty, staff, and graduate students acting as mentors. The positive impacts of these practices also extend to institutions, fulfilling institutional goals related to student learning. When community partners are involved, undergraduate research can also benefit the community.

Benefits for students

Numerous benefits to students conducting undergraduate research have been documented, including:

- Motivation and confidence to ask questions, learn and discover, and share knowledge (Russell et al., 2007; Lopatto et al., 2020).
- Acquisition and development of transferrable skills, like problem-solving, discipline-specific technical and analytical skills, reading and critical analysis of literature, synthesizing information, working as part of a team, writing, discussing, contextualizing, and presenting findings (Ishiyama, 2002; Lopatto, 2003, 2004; Seymour et al., 2004; Craney et al., 2011).
- Clarifying and confirming interest in the discipline and retention in the field (Lopatto, 2004; Seymour et al., 2004; Russell et al., 2007).
- Developing undergraduate students' identities as researchers and building research literacy through scaffolding skills in a course or program (Seymour et al., 2004; Linn et al., 2015).
- Learning to overcome obstacles through the iterative nature of the research process (Lopatto et al., 2020).

In the story below, Allison Cormier shares the benefits she received from conducting research through the Program for Undergraduate Research Experience (PURE).

"I received my first PURE Award in 2020, where I researched individual differences in online learning. After taking a clinical psychology course, I knew I wanted to explore clinical research. In 2021, I received my second PURE Award, where I researched the socialization of pain in popular media. My PURE Awards have had a domino effect in my personal and professional spheres. I still work with my 2020 PURE supervisor on research projects, and I will be completing my honours thesis with my 2021 PURE supervisor. When I reflect, what stands out the most is how much I've grown. It didn't happen in one moment, but as an accumulation of moments where I was challenged to push myself and adapt to new circumstances. Today, I am always looking to further my learning outside the classroom. There is something special about diving into a unique area in your field and being the one seeking (or creating) answers." - Allison Cormier, PURE Award recipient (2020, 2021), Department of Psychology

Benefits for faculty, staff, and graduate students

The benefits for those involved in supporting undergraduate researchers are many:

- When research is incorporated into the curriculum, there is often a greater enjoyment of teaching and a sense of self-fulfillment. Course instructors and staff build a better connection and relationship with students (Buddie & Collins, 2003; Shortlidge et al., 2016, 2017).
- Undergraduate research creates opportunities to integrate research with teaching and have undergraduates contribute to research programs and publications (Shortlidge et al., 2016, 2017).
- Undergraduate research initiatives can allow researchers to explore new research areas and directions in relatively low-stakes settings (Shortlidge et al., 2016).
- Incorporating research into teaching can help address the tension between some faculty members' identities as researchers rather than teachers, prompting pedagogical innovation (Brownell & Tanner, 2012).
- Many faculty members who develop undergraduate research opportunities go on to study and document their innovative practices through Scholarship of Teaching and Learning (SoTL) initiatives. SoTL can benefit faculty by sharing teaching and learning practices with a wider community and through connecting like-minded faculty in other disciplines or institutions (Shortlidge et al., 2016).

In the following story, Marcus B. Young, a graduate student in the Faculty of Arts, reflects on the impact of their undergraduate research mentoring experience on their research practices.

"I am in the first year of my MA, and my research specializes in aesthetics, visual culture, and queer photography. Dr. Maria Victoria Guglietti was my honour's supervisor, and when she pitched the COMS 591 Research Coach role, I was struck by how hands-on it was. At first, I assumed it was like a TA-ship, but once I started, that was not the case. I got to see how what I was teaching was also applicable to what I was doing in my own studies. Students would tell me stories or show me their work that made connections in ways that were exceptionally unique. Often, one makes assumptions based on years of experience, but those assumptions aren't necessarily obvious to students doing research for the first time. This prompted me to be more flexible, which surprised me. I learned to be more reflexive about research and research mentorship, and I am more in tune with the tensions between objectivity and subjectivity in my own work." - Marcus B. Young, Research Coach

Benefits for institutions

Engaging undergraduate students in research can also have benefits at an institutional level:

- Undergraduate research can support institutional goals of providing students with a quality education that enables them to be active members of their community and meet their career goals (Stukas et al., 1999; Cuthbert et al., 2012).
- Engaging undergraduates in research can increase the visibility of institutions in the research community and the public (Driscoll et al., 1996; Stukas et al., 1999).
- Retention of students in programs increases when research is incorporated into the curriculum, with additional evidence of increased retention for underrepresented identities in STEM (Nagda et al., 1998; Graham et al., 2013; Estrada et al., 2017).
- When institutions focus on providing more equitable and inclusive access to undergraduate research opportunities, the diversity of students engaged in research increases (Ishiyama, 2002; Graham et al., 2013; Bangera & Brownell, 2014; Estrada et al., 2017; Malotky et al., 2020).

Benefits for community

When undergraduate research is conducted in partnership with community organizations, there can be benefits to the community, including:

- Establishing collaborations between universities and the community and providing research support relevant and valuable to the community (Driscoll et al., 1996; Miron & Moely, 2006; Gazley et al., 2012).
- Increased visibility for the community's concerns and initiatives (Gazley et al., 2012).
- Helping connect, develop a network, and recruit future volunteers and employees for the community partner (Driscoll et al., 1996; Gazley et al., 2012).

The following story highlights collaborations between universities and communities in an undergraduate research course.

"When Dr. Mindi Summers and I first connected, she was looking to grow ZOOL 567 into a community-engaged learning course. My role was to collaborate with her in balancing community and university needs, while also being authentic to her vision for the course. In Fall 2021, Dr. Summers and I partnered ZOOL 567 with the Calgary Humane Society, the Alberta Farm Animal Care Association, and the Alberta Institute for Wildlife Conservation. Students researched a topic of interest to their community partner, like 'what kinds of enrichment activities minimize stereotypical behaviours in rescued animals?' Dr. Summers' and students' engagement with their community partners was astounding. They had so much energy and passion! Some students even asked if they could take their research projects to their own community partners, as they wanted to continue their research outreach to broader communities." - Laurel Sherriff, Community-Engaged Learning Specialist, Taylor Institute for Teaching and Learning

Additional resources

Discovery

- **Ideas for lab meetings activities**
- **UCalgary Library Guide for Research Data Management**

Dissemination

- **Strategies for Selecting, Managing, and Engaging Undergraduate Coauthors: A Multi-Site Perspective** (Scisco et al., 2019)
- **The "Writing Spiral": A Practical Tool for Teaching Undergraduates to Write Publication-Quality Manuscripts** (Giuliano, 2019a)
- **Guiding Undergraduates Through the Process of First Authorship** (Giuliano, 2019b)
- **Undergraduate students as co-producers in the creation of first-year practical class resources** (Hubbard et al., 2017)
- **UCalgary Library Guide for Research Posters**
- **UCalgary Library Guide for Scholarly Communication**
- The **Undergraduate Research in Science Conference of Alberta** (URSCA) is an annual meeting that "brings together students, faculty, and members of the academic community from across the province who are actively engaged in research activities and committed to advancing scientific innovation at the undergraduate level." Students can share their research through oral presentations and poster sessions.
- The **Alberta Academic Review** journal is a peer-reviewed journal open to all academic fields with a focus on "publishing high-quality, thought-provoking, well-researched work to both provoke and inform a general academic audience." Contact the editors If you are interested in submitting a poster as these are only accepted for special issue publications.
- The **Spectrum Journal** is a "student run, collaborative undergraduate research journal that is committed to producing thought-provoking, insightful and dynamic interdisciplinary content." Its submission formats are diverse and current undergraduate students in any faculty at any post-secondary institution can be published by Spectrum.
- The **Canadian Journal of Undergraduate Research** accepts submissions on a rolling basis and publishes its issues three times a year. Submissions can be original research, reviews, book reviews and research notes as described on the website. Submissions should be written to be accessible for the lay reader and non-native English speakers.
- The **Journal of Undergraduate Research in Alberta** (JURA) is a peer-reviewed, bi-annual journal based out of the University of Calgary. JURA publishes original research articles, case studies, methods, and extended abstracts of undergraduate researchers. It accepts article submissions with undergraduate students as primary authors. Articles and abstracts published in JURA are selected for their methodology, interpretation of results, quality of writing and accessibility for a wide audience. Novelty or level of contribution to respective research fields are not considered in the selection criteria.
- The **Journal of Young Investigators** is an international science publication open to undergraduate students mentored by a faculty member (holding an MD or PhD) from any institution. The journal has a "rolling submission" schedule and publishes original work at the first of each month.
- The **Journal of Student Research** is a multidisciplinary, faculty-reviewed publication that "seeks papers that are novel, integrative and written in a way that is accessible to a wide audience which includes an array of disciplines. The first author must be an undergraduate or graduate student currently enrolled at an academic institution. Note: Authors are required to pay an Article Processing Charge.
- The **Council of Undergraduate Research**'s mission is to "support and promote high-quality mentored undergraduate research, scholarship and creative inquiry..." One aspect of that is Undergraduate Research Highlights, which provides brief descriptions of peer-reviewed work with one or more undergraduate co-authors that

has “appeared in academic journals, book and book chapters, web-based publications and juried performances.”

- This **CUR** website provides an extensive list of undergraduate journals of a wide range of focus and disciplines. There are some Canadian and international journals institutions listed but the majority are associated with universities in the United States. Some of these focus on research being done at the home institution while others are open to promoting undergraduate research from around the world.
- Authors Liv Marken and DeDe Dawson of the University of Saskatchewan created this PDF available for download: ***Undergraduate Research Journals: Benefits and Good Practices of Involving Students in Content Creation and Other Scholarly Communication Activities***. As a Learning Specialist and Associate Librarian (respectively), they describe the University of Saskatchewan’s Undergraduate Research Journal (USURJ) and “relate our practical experience and suggestions for good practices should other libraries want to support similar journals.” They have also published ***Beyond Consumers: The Value of Engaging Undergraduate Students in Journal Management and Authorship***.

Reflection

- **Learning Module: Critical Reflection** - Taylor Institute for Teaching and Learning, University of Calgary
- **Online tutorials for helping students write reflectively**
- **University of Waterloo’s Reflective Frameworks and Prompts**
- Creating Self-Regulated Learners: Strategies to Strengthen Students’ Self-Awareness and Learning (Nilson, 2013)

Section II: Designing undergraduate research experiences

When designing and facilitating undergraduate research, it is important to carefully consider and align your research goals with the learning and research context. Laursen et al. (2010) identified four characteristics of a good undergraduate research project:

1. The research needs to start at a theoretical level that undergraduates are capable of understanding given their year of program and course background
2. Students should already have the skills required for the project or can learn the skills quickly enough so that they can make progress in the time available
3. The project should have a modest scope that can be simplified or extended if needed
4. The research should have a good chance of producing results within the timeframe available

Research context

In addition to these four characteristics and considerations of ethical, cultural, and social context, instructors or supervisors should carefully consider the students conducting the research and the unique research context. First, begin by completing a brief student researcher analysis using the following table and carefully consider the implications for the design of the research experience. This analysis can be completed for an individual student conducting a mentored research project or for a group of students conducting research in a course.

Student Research Analysis	Implications for Research Experience Design
STUDENT MOTIVATION AND INTEREST • How motivated are the students for research? Is this a required course, paid position, independent studies course? Was there an application process? • What are typical student attitudes toward the disciplinary content of the research? • What factors will motivate students during the research process? (i.e. intrinsic desire to find solutions to problems or extrinsic factors such as grades.) • What might students consider important learning outcomes or skills to develop through research? • What research goals or outputs do you anticipate will resonate with and motivate students?	
STUDENT EXPERIENCE WITH RESEARCH • What is the students' educational background? Year of program? • What previous research experience do students have? • What research skills have students developed in prerequisite courses or other research experiences? • What assumptions and preconceived ideas do students often have about research in your discipline? **Consideration:** If you are unsure of a student's experience with research, how might you gather this information? Could you discuss these questions with students at the start of the research term? In curricular research experiences, consider using a **Research Skills Survey** at the start of term to gauge student experience with research and skills. See the Additional Resources at the end of the section for samples.	

STUDENT AUTONOMY WHILE RESEARCHING

- How much support do you anticipate the students will need from you?
- Where should your mentorship fall in terms of high structure to low structure? How much structure and scaffolding will students need to be successful?

Consideration: When students are first developing research skills, the research process can be very prescribed with high structure provided by the instructor/mentor. The structure can be lessened as students gain skills. Experienced students may be engaged in unbounded research with very little structure provided by the mentor (Willison & O'Regan, 2007). Additionally, the degree of autonomy depends on time and resources and the nature of discovery. For example, student-driven troubleshooting is dependent on the availability of materials, space, time, and potential impacts. Use Appendix C to explore where your students fall regarding research skill development and autonomy (RSD Framework).

Next, analyze the research context in terms of scale, collaboration, depth, logistics, ethics and explore implications for your design. Good design is iterative, so keep revising and revisiting these questions as you design your research experiences. At the end of this section, you will find reflective and evaluative questions to prompt you to pause and consider your design during and after the research experience.

Research Context Analysis	Implications for Research Experience Design
TIME SCALE OF THE PROJECT • How much time does a student have to dedicate to their research? • Is this project short-term (a few weeks) or long-term (8 months to 1 year)? • Are students working on their research for just a few hours per week, in addition to other course work, or does the student have full-time hours to dedicate to research?	
COLLABORATION • Will the project be conducted independently or in a team? • Will the team consist of graduate students or other research mentors? What experience do others involved in the research have with mentoring undergraduate researchers? • Will there be collaborators external to the University? Who are the partners? • What other resources can be accessed to support students (i.e. library, writing center, students conducting similar research, research guides)?	

EXTENT OF INVOLVEMENT IN THE RESEARCH PROCESS • Will students engage with the entire research process from start to finish, or will the project focus most intensely on one or a few components of the research process? • Will students develop their research question, or will they be given the question? **Consideration:** With an awareness of the entire research process, students conducting research may successfully engage in one component of the research process (i.e. data collection) or the entire process.	
LOGISTICS • What is the setting for the research (i.e. library, lab, field)? • What are some constraints on the research (i.e. time, budget, other resources)? • Are there particular time points that will be stressful during the research (in the research experience or beyond)? • What are realistic deadlines or project milestones? • How can the experience be designed not to be overwhelming?	
ETHICS • Will the project need research ethics or animal care approval? • Will permits be required to collect data?	

Backwards designing an undergraduate research experience

There is value in all forms of research, whether it is a two-week, highly guided literature-based project or a year-long unbounded research experience. Regardless of the scale, structure, or depth, the goal is to design the experience to ensure deep learning while meeting research goals and outputs. Given the context outlined in this section, we encourage using the principles of "Backwards Design" (Wiggins & McTighe, 1998) to develop and plan the research experience.

Backwards design

Backwards design is a strategy where you "begin with the end in mind" and consider what students should be able to do, learn, or produce at the end of an experience (Powell & Harmon, 2016; Allen & Tanner, 2007). Once the endpoint is articulated, you work backwards to consider how students will develop the skills needed to reach the desired endpoint.

Research Comprehension & Communication Skills
- Develop disciplinary knowledge
- Develop research communication skills
- Develop logic/critical thinking skills
- Develop understanding of the research environment
- Develop responsible and ethical research practices
- Develop effective interpersonal communication skills

Practical Research Skills
- Develop ability to design a research project
- Develop ability to conduct a research project

Research Ethics
- Develop responsible and ethical research practices

Researcher Identity
- Develop identity as a researcher

Professional & Career Development Skills
- Explore and pursue a research career
- Develop confidence in pursuing a research careeer

Equity & Inclusion Awareness & Skills
- Advance equity and inclusion in the research environment
- Develop skills to deal with personal differences in the research environment

Researcher Confidence & Independence
- Develop independence as a researcher
- Develop confidence as a researcher

Butz and Branchaw's (2020) "Entering Research" conceptual framework identifies seven dimensions of learning objectives for research. To begin the backwards design process, consider which are particularly important for students in your research context? Are there some outcomes you want to focus more on for trainee development?

To start, consider the following:

1. What are the goals for the research?

2. Research activities and learning outcomes for students

What do you want students to do or produce through their research experience?	Why are these skills or learning outcomes important?

3. Alignment of learning outcomes, activities, and assessment

LEARNING OUTCOMES What skills or knowledge will students need to develop to meet the research goals?	ACTIVITIES What will students do to develop and practice these skills? How will they receive feedback as they practice?	ASSESSMENT What will students produce through these activities? What will be assessed?

4. How will you assess or evaluate the research process in addition to the products?

5. How will you promote students' curiosity, discovery, dissemination, and reflection? (See Section I for the discussion on how these four elements create a high-quality research experience)

Curiosity	
Discovery	
Dissemination	
Reflection	

Reflecting on and evaluating student learning

Designing and facilitating impactful, high-quality learning activities requires an iterative approach informed by reflection. Your reflection and exploration of student learning can occur throughout the learning experience. Prompts for your reflection activities can include reflective questions, surveys and questionnaires, analysis of student work, and other sources.

Below are some reflective questions (adapted from Tanner, 2012) to consider during and after the research experience.

	REFLECTING	EVALUATING
During the experience	• What have I noticed about students during the research experience? • What strategies am I using that appear to be facilitating students' research or impeding their research? • What could I do right now to improve the experience?	• How do I think the research is going? Why do I think that? What evidence do I have? • To what extent are students meeting the research goals? • How does the research progress compare to the proposed timeline and milestones?
After the experience	• What worked well? What didn't work? • How has this experience changed my views on research, teaching, or mentorship? • Were there times when I was particularly motivated or excited during the experience? • What was most rewarding? • If I were to do this again, what would I change? Why? What might keep me from making those changes?	• What evidence do I have that students developed specific research skills? • To what extent did the assessments measure students' learning or skill development? • To what extent were the research goals met?

Surveys and questionnaires: There are many general and field-specific survey tools and questionnaires developed to explore student and trainee perceptions of skill development and growth. For example, consider using Entering Research Learning Assessment (ERLA) (Butz & Branchaw, 2020) or other survey tools provided in the Additional Resources at the end of this Section.

Your reflections, students' reflections, and student work can provide evidence of teaching effectiveness in teaching dossiers and other materials. If you plan to use student work, ideas, or survey results to document and reflect on your teaching and mentorship practice, be sure to ask for student permission. It is also good practice to invite students to share their work and experiences in any dissemination.

Scholarship of Teaching & Learning (SoTL)

Instructors interested in more formalized investigations of teaching and learning in their context are encouraged to explore Scholarship of Teaching and Learning (SoTL). SoTL resources on getting started and applying for funding are available through the Taylor Institute. Engaging in SoTL requires human ethics approval through institutional CFREB boards, prior to the start of collecting any student data.

Additional resources

Research skills surveys

- **Entering Research Learning Assessment (ERLA): Validity Evidence for an Instrument to Measure Undergraduate and Graduate Research Trainee Development** (Butz & Branchaw, 2020)
- **How to assess your CURE: A practical guide for instructors of Course-based Undergraduate Research Experiences** (Shortlidge & Brownell, 2016)
- **Evaluating Undergraduate Research Experiences—Development of a Self-Report Tool** (Maltese et al., 2017)
- **EvaluateUR** – Online undergraduate research evaluation tool [Requires a subscription]
- **The Undergraduate Research Student Self-Assessment (URSSA): Validation for Use in Program Evaluation** (Weston & Laursen, 2017)

Evaluation of undergraduate research to provide evidence of teaching effectiveness

- **Guide for Providing Evidence of Teaching Effectiveness** - Taylor Institute for Teaching and Learning, University of Calgary

Evaluation of undergraduate research for SoTL research

- **Ethics in the Scholarship of Teaching and Learning** - Taylor Institute for Teaching and Learning, University of Calgary

Section III: Mentorship of undergraduate research

"At its best, mentoring can be a life-altering relationship that inspires mutual growth, learning, and development. Its effects can be remarkable, profound, and enduring; mentoring relationships have the capacity to transform individuals, groups, organizations, and communities." - Ragins and Kram (2007)

The quality of mentorship can greatly impact a student's experience during research. Mentoring relationships are both professional and personal. Mentors act as role models, guides, instructors, facilitators, and sponsors to assist students in being successful academically and in their careers. When mentoring undergraduates, it is important to remember that they are not graduate students. Mentors must understand and accommodate students' varying levels of preparation, skills, and abilities. Some undergraduates will be as capable as graduate students. However, many will not have developed the knowledge base and skills of graduate students. Mentoring undergraduates can involve more time spent with hands-on training, helping to set realistic goals and timelines, and exploring career and professional aims (Anderson & Shore, 2008; Temple et al., 2010; Palmer et al., 2015).

"Mentorship is a defining feature of undergraduate research." - Shanahan et al. (2015)

In the next story, Dr. Ariane Cantin shares her experience mentoring an undergraduate researcher in the Program for Undergraduate Research Experience (PURE).

"For me, undergraduate research is about collaborating with students. They have a lot of great ideas and see connections I wouldn't necessarily see. I had never supervised a PURE student before, but Mackenzie was very convincing in wanting to work with me and in finding a water issue in Calgary that was of interest to them. We connected with a wetlands specialist and reviewed the literature. There hadn't been much research on wetlands in city water systems, and Mackenzie was interested in invertebrates, often used as indicators for water quality in an ecosystem. We reached out to Mount Royal University and the City of Calgary to piggyback our research project on data previously collected. As a PURE supervisor, I learned to let students have time to think for themselves, rather than me telling them what I would do. I've started doing this in my courses, too. I really want to work together with students to find answers and take a reflective approach to the research process." - Dr. Ariane Cantin, PhD, PURE Supervisor (2021), Department of Biological Sciences

Undergraduate students typically interact with and work with multiple mentors such as peer mentors, graduate teaching assistants, staff, faculty, and outside partners. As described in the **Taylor Institute Mentorship Guide for Teaching and Learning**, successful and impactful mentoring can take many forms: dyad (one-on-one), peer, group, constellation (network), or distance where mentors are in different locations from mentees. Mentorship and advising can also exist with people and units outside of the research project, such as librarians, student advising, student academic support, writing centres, and more. To support undergraduates engaging in research, particularly for students in equity-deserving groups, taking the time to help students build a strong mentoring network or constellation is important for long-term career success (Estrada et al., 2017).

Just like any skill, mentorship is a practice that can be developed. This section outlines important practices for mentoring undergraduate researchers and provides an opportunity for individuals to reflect on their mentorship practices.

Integral components of mentoring undergraduate research

Undergraduate research mentoring involves different types of support from the mentor: 1) intellectual support where the mentor guides the student through problem-solving and helps the student progress through their work; 2) personal and emotional support to make the student feel supported and comfortable interacting with their mentor; and 3) professional support where the mentor shares skills and norms that are important to progress in the discipline (Thiry and Laursen 2011, Shanahan et al., 2015).

Based on a literature review, Shanahan et al. (2015) identify the following ten key practices of undergraduate research mentors:

10 Salient Practices of Undergraduate Research Mentors

1. Do strategic pre-planning to be ready to respond to students' varying needs and abilities throughout the research process.
2. Set clear and well-scaffolded expectations for undergraduate researchers.
3. Teach the technical skills, methods, and techniques of conducting research in the discipline.
4. Balance rigorous expectations with emotional support and appropriate personal interest in students.
5. Build community among groups of undergraduate researchers and mentors, including graduate students, postdoctoral fellows, and any other research team members.
6. Dedicate time to one-on-one, hands-on mentoring.
7. Increase student ownership of the research over time.
8. Support students' professional development through networking and explaining the norms of the discipline.
9. Create intentional, laddered opportunities for peers and "near peers" to learn mentoring skills and to bring larger numbers of undergraduates into scholarly opportunities.
10. Encourage students to share their findings and provide guidance on how to do so effectively.

Take some time to reflect on your strengths concerning these 10 Salient Practices. Consider what you are doing well and identify areas or ways to improve your practice.

10 Salient Practices	What are my strengths in this practice? How am I incorporating this practice, and what am I doing well?	How could I improve in my practice? Where am I facing challenges?
Do strategic pre-planning to support students' varying needs and abilities during the research process Suggestions: • Invest time early in the process for project selection and planning • Identify students' background preparation and level of skills in different areas • Set achievable timelines • Don't underestimate the potential for authentic scholarship		
Set clear and well-scaffolded expectations Suggestions: • Attend to students' fluctuating needs at different points in the process • Provide strong support early on • Gradually give students more autonomy • Outline your expectations with students in learning contracts or syllabi • Discuss expectations and commitments for interpersonal dynamics, communication, and how to handle conflict		

Teach the technical skills, methods, and techniques of conducting research in the discipline Suggestions: • Introduce students to the expectations of research in your discipline • Guide students through the technical practices needed to support project goals (e.g., protocols for labs, databases, studios, archives, software) • Emphasize the importance of ethical standards and safety		
Balance rigorous expectations with appropriate emotional support Suggestions: • Set expectations for excellence, but not perfection • Provide positive yet constructive feedback • Remain approachable to minimize anxiety and bolster confidence; normalize experiences and feelings, particularly the lack of confidence many feel • Adapt your emphasis to suit students' needs • Be available and consistent, and prioritize making time for mentoring • Solicit and reflect on feedback regarding your mentorship		
Build community among groups of students or a research team Suggestions: • Build trusting interpersonal relationships on the team • Practice intentional team development • Engage the team in common interests and non-research activities to foster connections		

Dedicate time to one-on-one mentoring Suggestions: • Minimize false assumptions regarding ability and progress • Provide personalized guidance and advice • Exemplify the value of time-intensive, hands-on mentoring experiences with students		
Increase student ownership over time Suggestions: • Explain how student tasks relate to larger project goals • Welcome student opinions about their work • Listen with patience and openness • Foster autonomy by giving students ownership of specific tasks and important aspects of the overall project		
Support students' professional development Suggestions: • Understand and discuss students' career and professional goals • Identify students' vocational identities and needs (identify a career route; specific targeted career advice; etc.) • Provide networking opportunities by introducing students to colleagues on campus and at conferences • Students often report that networking opportunities in informal environments are even more meaningful than presenting research at conferences • Write strong, specific letters of recommendation		

Create intentional, laddered opportunities for peers or near-peers to learn mentoring skills Suggestions: • Create intentional opportunities for peers and near-peers (graduate students, postdocs) to learn mentoring skills • Identify and foster different mentoring roles depending on students' expertise and experience • Model the characteristics of a successful researcher as well as those of a successful mentor • Provide guidance for expectations of the relationships		
Encourage students to disseminate their findings Suggestions: • Develop avenues for dissemination; this is essential to student understanding of what it means to be a scholar • Have students present work both informally and formally to peers, experts, and community • Take students to conferences		

Research with undergraduates requires establishing and maintaining collaboration—the two-way flow of ideas and information—for the project's duration. Transitioning and growing as a researcher and mentor will be challenging for all involved—with forward movement and setbacks—and it is important to anticipate and plan for challenges. Research is the first time many students will be encountering failure and having to do the same thing multiple times. Mentors may be experiencing unlimited demands on their time and need to establish boundaries and communicate the invisible time and effort they are putting into their students. As students become increasingly independent and grow confident with research, mentorship activities will change to support this progression. Below are some checkpoints to aim for as students begin, develop, and transition through a research experience.

Beginning	Developing	Transitioning
Introductions to the research team	Students develop skills and practices in the field	Students share work
Establishing motivation and buy-in	Students develop an awareness of the research context	Celebrate research accomplishments
Identifying skills and areas for improvement	Students begin to improve and/or develop protocols and methodology of research	Celebrate and mark the transition to the next stage of students' career
Safety training and ethics	Mark important milestones in the research process	Reflect on research experience
Research organization (record-keeping and back-up)	Ongoing reflection on research experience	Solicit feedback from students on experience and how to improve
Building rapport and trust	Identify goals for sharing work	
Sharing of resources and support (e.g., library, writing centre, workshops and training)	Solicit and integrate student feedback and ideas (e.g., class representative)	
Communication plan		
Planning for conflict and disagreement		
Developing goals for the project		

Based on the ideas in the Section, what are three goals you can set for the next six months? Aim to develop SMART goals (Specific, Measurable, Actionable, Realistic, Timebound)

1.
2.
3.

Additional resources

- **The Mentorship Guide for Teaching and Learning** – Taylor Institute for Teaching and Learning, University of Calgary
- **Learning Module: Critical Reflection** - Taylor Institute for Teaching and Learning, University of Calgary
- **10 Salient Practices for Undergraduate Mentorship**
- **UCalgary Wellness Services**
- **Entering Research**
- **Entering Mentoring**
- **Ethical Issues and Concerns Associated With Mentoring Undergraduate Students** - (Anderson & Shore, 2008)

Self-assessing competencies in mentorship of undergraduate research

- **The Mentoring Competency Assessment: Validation of a new instrument to evaluate skills of research mentors** (Fleming et al., 2013)

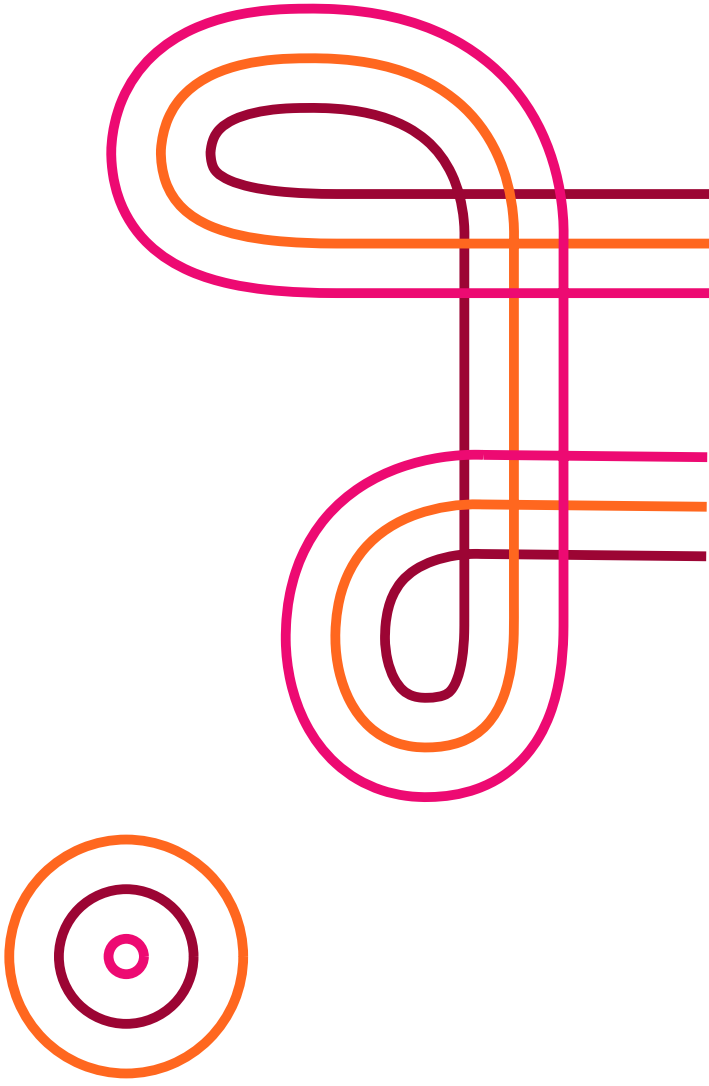
Final thoughts

Throughout this guide, we have explored how undergraduate research experiences intentionally evoke students' curiosity, engage students in the discovery process, ensure opportunities to disseminate findings, and extend learning through critical reflection. Section I defined high-quality undergraduate research and outlined the many benefits of engaging undergraduates in research for students, graduate students, faculty members, institutions and the community. Section II prompted designers to consider their unique research context and begin with-the-end-in-mind to generate research activities and assessments that foster research skill development. Lastly, Section III provided strategies for developing intentional, supportive mentorship to create opportunities for students to take risks, develop as people and professionals, and build resiliency by overcoming challenges arising during research.

We hope this guide has inspired you to explore more ways to support the deep experiential learning that occurs when undergraduates participate in research. Mentoring undergraduates as they develop research skills is demanding work, but it is also rewarding. We hope the approaches outlined in the guide help lessen the challenges and heighten the sense of satisfaction.

To those just getting started with undergraduate research, allow us to leave you with some advice: start small. Consider turning a single course module into a research experience, get students to share their research-based assignments beyond the class/lab limits, or start with re-designing a single assignment to develop targeted research skills. When examining your mentorship practice, focus on making just one change at first. Once that small change has become part of your practice, consider what else you can add to your mentorship repertoire. To those who have mentored undergraduate researchers for years, we hope to have equipped you with some new insights, considerations, or inspiration to consider more ways to support undergraduate research for more students to benefit.

Finally, we invite you to share your experiences. We are keen to hear what works for you, what barriers and obstacles you face, and what strategies you use in designing and mentoring undergraduate research experiences. We envision this guide as a dynamic and evolving document that can capture ideas and approaches. As the guide evolves, we would love to know what aspects are particularly useful? Where would more information or resources prove helpful? What tools are less effective for you? How can we work together to enhance undergraduate research at UCalgary?



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Appendix A

Research question frameworks

Several research question *frameworks* exist that can help you to refine, clarify, and more precisely articulate your research question. Different frameworks are better suited for certain types of research. For the six frameworks provided below, determine which framework **best fits with your research**. Use the framework to ensure you include the essential components in your research question by filling in the table's last column. Once you have considered the question framework's aspects, refine your research question to include these components.

PICO	Explanation	Your research
P – Patient, Population, or Problem	Who and/or what does my question focus on?	
I – Intervention	What intervention is being considered? (if appropriate)	
C – Comparison	What intervention is this being compared with? (if appropriate)	
O – Outcomes	What do you hope to accomplish, improve or affect?	

PICo	Explanation	Your research
P – Patient, Population, or Problem	Who and/or what does my question focus on?	
I – Interest	A defined event, experience, activity, or process	
C – Context	A setting or distinct characteristic	

PEO	Explanation	Your research
P – Population	Who is my question focused on?	
E – Exposure	What is the issue I'm interested in?	
O - Outcomes or themes	What about the issue do I want to examine?	

SPICE	Explanation	Your research
S – Setting	Where is the study set, e.g. specific country, community, hospital?	
P – Perspective	From whose perspectives is the study done?	
I – Intervention	What is the intervention being examined?	
C – Comparison	Is the intervention being compared with another?	
E – Evaluation	Outcomes measured	

SPIDER	Explanation	Your research
S – Sample	The group of people being looked at (particularly for qualitative research)	
PI – Phenomenon of Interest	Research of behaviour and decisions, rather than an intervention	
D – Design	The method of research used, such as interview or survey	
E – Evaluation	Outcome measured	
R – Research type	Qualitative, quantitative, mixed methods	

ECLIPSE	Explanation	Your research
E – Expectation	What is the information needed for?	
C – Client group	Who is the information needed for?	
L – Location	Where is the client group or service located?	
I – Impact	What is the change that is being looked for? What would constitute success? How is this being measured?	
P – Professionals	What professionals are involved?	
S – Service	For which service are you looking for information?	

Refined research question:

Adapted from: **https://libguides.city.ac.uk/postgraduate_research/frameworks**

Appendix B

Research planning guide

Part I: Research question & objectives

Task 1 - Watch: Developing a Research Question

What is your Research Question?

How does your research question address all five "SMART" components? If it doesn't, can you modify your question so that it is Specific, Measurable, Achievable, Relevant, and Timely?

Specific	
Measurable	
Achievable	
Relevant	
Timely	

Research Project Objectives

Task 2 - Watch: Mapping an Area of Inquiry

Task 3 - Watch: Selecting a Research Method

What are your project research objectives? Think about what your research project can achieve. Consider what objectives are within the scope of the project and what objectives are not. What research methodologies do you anticipate using? What questions do you have about your research methodology?

Part II: Personalized learning outcomes

Task 4 - Read: Research Skills Development Framework

In preparation for your research, you will write personalized learning outcomes that clearly describe what you will be able to "do" or skills you will be able to "apply" as a result of your experience. Each learning **outcome** is achieved through a given set of **activities** that result in a **product** that is measurable by **criteria** you and your supervisor agree upon.

TO START, LET'S EXPLORE THE FOLLOWING QUESTIONS:

1. What do you want to be able to do, or achieve, as a result of your research? Try to develop at least 3 outcomes. (Outcomes)

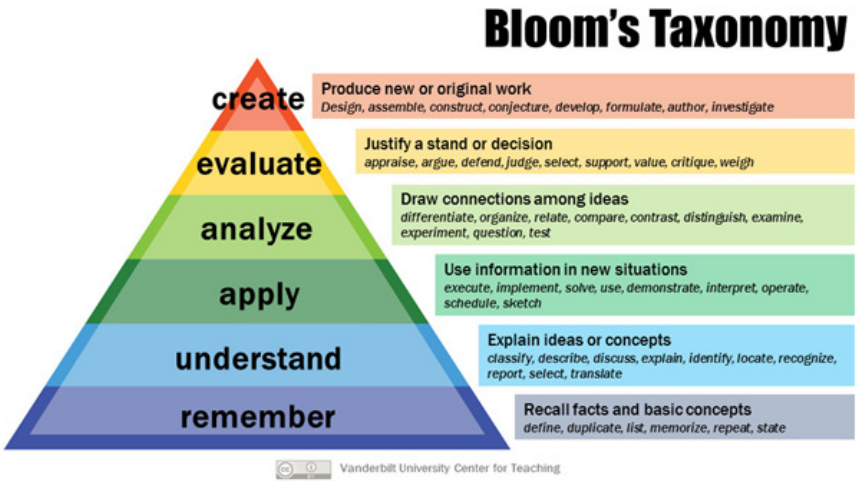
2. What activities will you engage in during your research to accomplish this outcome? (Activities)

3. What product/evidence will you produce to demonstrate that you have accomplished your outcome? Products can be in various forms such as reports, performances, presentations, videos, digital posters, installations, exhibits, scores, performances, abstracts etc. (Products)

4. What standards will be used to judge the quality of your product? Your criteria define the quality that is expected for each of your products. Strive for at least 3 criteria for each product. Start by identifying descriptive keywords (i.e. clearly, accurately) for each criterion and then define them. (Criteria)

REFINE YOUR OUTCOMES AND CRITERIA

Next, let's refine the language you use for your learning outcomes so they are strong, definitive statements. Rather than describing outcomes passively, such as "to learn about" or "to study," refine your learning outcomes using verbs such as "evaluate" or "analyze" from Bloom's Taxonomy (below).



1. Write out your revised outcomes using definitive, demonstrable verbs.

2. Now it's time to **refine your criteria.** Using the keywords to describe your product(s) from the previous section, define what those keywords mean in the context of your research. For example, your product may need to be *accurate, well-organized,* and *visually appealing*. You can then **define** what these keywords mean in the context of your research project (i.e. Accurate = Material is presented without errors or misinterpretations).

Using your refined outcomes, activities, products, and criteria statements complete the Learning Outcomes Grid (below). Use this grid as a guide for your development, communication, and checkpoint tools for you and your supervisor. It will be important to discuss your learning outcomes, activities, products and criteria with your supervisor on an ongoing basis throughout your research term.

PERSONALIZED LEARNING OUTCOME GRID

<table>
<tr><th>Outcome</th><th>Activity</th><th>Product (Evidence)</th><th>Criteria</th></tr>
<tr><td colspan="4">Prompting questions:</td></tr>
<tr><td>What will I be able to do as a result of this research?</td><td>Which actions or activities do I need to complete to achieve this outcome?</td><td>What products will prove that I accomplished this outcome?</td><td>How will I know if this product is of high-quality?</td></tr>
<tr><td colspan="4">Keywords:</td></tr>
<tr><td>Analyze, assess, evaluate, create, survey, etc.</td><td>Learn techniques and procedures, practice, etc.</td><td>Supervisor approval, database, reports, presentations, etc.</td><td>Accurate, useful, organized, effective, etc.</td></tr>
<tr><td rowspan="3">Outcome 1:</td><td rowspan="3"></td><td rowspan="3"></td><td>Criteria 1:</td></tr>
<tr><td>Criteria 2:</td></tr>
<tr><td>Criteria 3:</td></tr>
</table>

Outcome 2:			**Criteria 1:**
			Criteria 2:
			Criteria 3:
Outcome 3:			**Criteria 1:**
			Criteria 2:
			Criteria 3:

Part III: Timeline for research

Task 6 - View: Project Timeline Template (PPT)

When starting a new project, it is essential to create a project plan and a timeline. This is particularly important when working remotely as time can slip away from you!

The first step in creating a project timeline is to divide your research into distinct phases that you can mark with clear milestones. Phases you might include are: defining project scope, designing research study, executing research plan or methodology, analyzing data, synthesizing findings and sharing results or reflecting on experience. Begin to identify **big, medium,** and **small tasks** associated within each phase. For example, big tasks might be analyzing data or writing-up the final project; medium tasks might be to read an article or organize your references; small tasks might include checking emails or formatting a table. **Big tasks can be starred as milestones that visibly mark progress in your research project as you move through the phases.**

Once you have a high-level overview of your project, discuss your timeline with your supervisor to ensure your estimated timeframe is realistic and all the required steps and tasks are included. As you pass milestones, be sure to check-in with your supervisor to recognize your accomplishments and discuss the remaining timeline.

You may consider keeping two timelines:

> **Timeline 1** – This will be *shared with your supervisor* so they can understand what phase you are at in your research. This timeline can be less detailed than Timeline 2, showing only higher-level goals and big tasks that you update once a month or as requested by your supervisor.
>
> **Timeline 2** – This is for **YOU!** This timeline can be more detailed than Timeline 1, breaking down the medium and small tasks between the big tasks. This timeline should be updated weekly to reflect modifications to your project and to keep you on track in meeting your goals.

You could also use a **daily planner** to schedule in other commitments – family, friends, exercise, employment, etc. and to include the smaller day-to-day responsibilities or accomplishments.

HOW TO MAKE A TIMELINE

- Create a list of all tasks associated with completing your research.
- Organize and label the tasks in chronological order.
- Categorize size of the tasks (big, medium, small) by colour.
- Choose a timeline design (see “Designing Your Timeline” section below).
- Add big tasks to the timeline first.
- Copy over Timeline 1 and create Timeline 2 including the medium to small tasks.

DESIGNING YOUR TIMELINE

Task 7 - Research various timeline designs and find one that suits you. Here are some common types to help get you started:

- **Gantt Chart** - this timeline is displayed as bars reflecting periods of time it will take to complete each task listed.
- **PERT Chart** - this timeline is a good way of showing how one task must be completed before another is created (dependency). However, it can be harder to edit.

- **Work Breakdown Structure (WBS)** - this timeline is captured in a diagram that flows downwards and shows how a particular task can be broken into smaller sections.
- **Traditional timeline** - a linear model showing the chronological order that a project will take place. This works well for milestone deadlines.

Tips:

- Colour code groups of tasks based on themes
- Make sure the timeline is easy to edit
- Have a clear hierarchy of tasks
- Leave room for time extensions, tasks will often take ~ 2.5 times longer than we realize

FREE PROJECT MANAGEMENT TOOLS

There are lots of free online project management tools, for example:

- **Trello**
- **Asana**
- **Monday**

Or if you like to go with paper, check out:

- **Bullet Journal**
- **Passion Planner**

Begin to sketch out your project timeline.

Appendix C

Research Skill Development Framework

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Research Skill Development Framework

For educators to facilitate the explicit, coherent, incremental and cyclic development of the skills associated with researching, problem solving, critical thinking and clinical reasoning.

Scope for Student Autonomy

Facets of Research	Students develop research mindedness when they…	Prescribed Research Highly structured directions and modelling from educator prompt researching, in which…	Bounded Research Boundaries set by and limited directions from educator channel researching, in which…	Scaffolded Research Scaffolds placed by educator shape independent researching, in which…	Open-ended Research Students initiate research and this is guided by the educator.	Unbounded Research Students determine guidelines for researching that are in accord with discipline or context.
Curious	**Embark & Clarify** *What is our purpose?* Students respond to or initiate direction, clarify and consider ethical, cultural, social and team (ECST) issues.	Students respond to questions/tasks that are directed. Use a provided, structured approach to clarify questions, terms, requirements, expectations and ethical, cultural, social and team issues.	Students respond to questions/ tasks with limited options. Choose from several provided structures to clarify questions, requirements, terms, expectations and ethical, cultural, social and team issues.	Students respond to broad tasks/ questions given. Choose from a range of provided approaches or structures to clarify requirements, questions, expectations and ethical, cultural, social and team issues.	**Students generate questions /aims/hypotheses/purpose framed within structured guidelines*.* Anticipate and prepare for ethical, cultural, social and team issues.	**Students generate questions/aims/ hypotheses/purpose based on experience, expertise and literature.* Delve into and prepare for ethical, cultural, social and team issues.
Determined	**Find & Generate** *What will we use?* Students find information and generate data/ideas using appropriate methodology.	Students collect and record required information/data using a prescribed methodology from a prescribed source in which the information/data is evident.	Students collect and record appropriate information/data using given methodology from pre-determined source/s where information/data is not obvious.	Students collect and record appropriate information/data from self-selected sources using one of several provided methodologies.	Students collect and record self-determined information/data choosing an appropriate methodology based on parameters set.	Students collect and record information/data from self-selected sources, choosing or devising an appropriate methodology with self-structured guidelines.
Discerning	**Evaluate & Reflect** *What will we trust?* Students determine the credibility of sources, information, data and ideas, and make their own research processes visible.	Students evaluate sources/ information/data using simple prescribed criteria to specify credibility and to reflect on and improve the process used.	Students evaluate sources/ information/data using a choice of provided criteria to specify credibility and to reflect on and improve processes used.	Students evaluate sources/ information/data and the processes to find/generate, using criteria related to the aims of the inquiry to reflect on and improve processes used.	Students evaluate information/data and the inquiry process using self-determined criteria developed within parameters given. Reflect to refine own and others' processes.	Students evaluate information/data and inquiry process rigorously using self-generated criteria based on experience, expertise and the literature. Reflect to renew own and others' processes.
Harmonising	**Organise & Manage** *How do we arrange?* Students organise information & data to reveal patterns/themes, managing teams and processes.	Students organise information/data using prescribed structure. Manage linear process provided (with pre-specified team roles).	Students organise information/data using a choice of given structures. Manage a process which has alternative possible pathways (and specify team roles).	Students organise information/data using provided guidelines to choose structures. Manage processes (and teams) with multiple possible pathways.	Students organise information/data using self-determined or group-determined structures, and manage the processes (including team function) within the parameters set.	Students organise information/data using self-determined or group-determined structures and management processes (including team function).
Creative	**Analyse & Synthesise** *What does it mean?* Students analyse information/data critically and synthesise new knowledge to produce coherent individual/team understandings.	Students interpret given information/data, determine patterns and synthesise knowledge into prescribed formats. **Ask emergent questions of clarification/curiosity*.*	Students analyse trends or themes in several sources of information/ data and synthesise to integrate knowledge into provided standard formats. **Ask emergent, relevant and researchable questions.**	Students analyse trends or themes in information/data and synthesise to fully integrate component parts in structures that are appropriate to task. **Ask rigorous, researchable questions based on new understandings*.*	Students analyse information/data and synthesise to fully integrate components, consistent with self-determined parameters. Fill knowledge gaps that are stated by others.	Students analyse and synthesise information/data to generalise or abstract knowledge that addresses self-identified or group-identified gaps in understanding.
Constructive	**Communicate & Apply** *How do we relate?* Students apply their understanding and discuss, listen, write, perform, respond to feedback and present processes, knowledge and implications of research, heeding ethical, cultural, social and team (ECST) issues and audience needs.	Students discuss with each other, listen, read and write to relate their prior and new knowledge to set tasks. Use prescribed language and genre to develop understanding and then demonstrate this to a specified audience. Apply to a similar context the knowledge developed. Follow prompts on ECST issues.	Students use some discipline-specific language and genre to relate their prior and newly developed knowledge to tasks and then to a specified audience. Apply the knowledge developed to several similar contexts and stay within boundaries set for ethical, cultural, social and team issues.	Students use discipline-specific or other appropriate language and select genres to develop understanding and relate this to an audience chosen from given options. Apply the knowledge developed to different contexts and specify the ethical, cultural, social and team issues that emerge.	Students choose appropriate language, genre and performance to extend the knowledge of an audience they have selected. Apply the knowledge developed to diverse contexts and specify ethical, cultural, social and team issues in initiating, conducting and communicating.	Students choose appropriate language, genre and performance to extend the knowledge of a range of audiences. Apply innovatively the knowledge developed to multiple contexts. Probe and specify ethical, cultural, social and team issues that emerge broadly.

Research is not merely gathering more information and generating more data. Research is engaging in all the above facets, time and again.

The RSD, a conceptual framework for Early Childhood to PhD, by John Willison and Kerry O'Regan, with much trialling by Eleanor Peirce and Mario Ricci. October 2006, revised November, 2019. Facets based on: ANZIIL (2004) & Bloom et al. (1956; 1964) Taxonomies: Perpendicular text reflects learning attitudes. Scope & autonomy inspired by Vygotsky (1980). Extent of synthesis is informed by SOLO taxonomy (Biggs & Collis, 1982). ** Framing researchable questions often requires a high degree of guidance and modelling for students and results from their synthesis (Red, Yellow), then initiates their research (Green & Blue).* Six facets may be used directly with students as a 'thinking routine' (Ritchhart & Perkins 2008). Resources and articles available at www.rsd.edu.au email: john.willison@adelaide.edu.au The RSD is the first of the MELT. www.melt.edu.au

A Guide for Undergraduate Research at UCalgary

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