INQUIRY-BASED LEARNING (IBL) AS A DRIVER OF CURRICULUM: A STAGED APPROACH

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Inquiry-based learning (IBL) provides students with an opportunity to take ownership of their learning while developing important higher-order skills necessary for designing innovative solutions to complex modern health problems. In our undergraduate health sciences program, critical thinking, creativity, research skills and innovative thinking are core program learning outcomes, and thus IBL is an important pillar of our curriculum. We have taken a staged approach, integrating IBL into each year of a four-year undergraduate degree program that scaffolds structure and independence to suit undergraduate student needs from the first to third years; this culminates in an independent, student-driven honours thesis in the fourth year. In this paper, we share practical IBL strategies that pair with student needs throughout the four-year continuum and highlight strategies to address challenges at each stage of learning.

Keywords: Inquiry-based learning; undergraduate; scaffolding; inquiry curriculum

Inquiry-based learning (IBL) is a student-centered pedagogy that puts students in control of their learning (Spronken-Smith, Walker, Batchelor, O'Steen, & Angelo, 2011). Rooted in a constructivist approach, IBL focuses on experiential processes that allow students to participate in both knowledge acquisition and construction, resulting in more engaged and deeper learning than traditional didactic instructional practices (Hmelo-Silver, Duncan, & Chinn, 2007; Justice et al., 2007; Levy, Little, McKinney, Nibbs, & Wood, 2010). An IBL curriculum organizes learning around questions and problems that are authentic and disciplinarily relevant, and requires student-centered teaching practices that support the inquiry process (Levy et al., 2010).

Justice et al. (2007) describe the inquiry process as beginning with the acquisition of foundational knowledge that students use to explore an inquiry question, which may be either student or instructor generated. Learners then identify resources, gather information, and assess its quality, and synthesize the evidence, sometimes iteratively refining the inquiry question and consulting new sources until the inquiry question is adequately addressed. The inquiry cycle is not complete until learners communicate their new understandings and evaluate the results of the inquiry process. The process is circular – the completion of one inquiry cycle often results in new interests and additional questions that motivate further inquiry (Justice et al., 2007).

Effective IBL curricula must provide students with the foundational knowledge, resources and skills required, and, as needed, at each point during the inquiry cycle. Furthermore, IBL activities should align with the learner's level of knowledge (novice versus senior learner) and ability to be an independent learner. In this paper, we outline a framework for a four-year

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undergraduate IBL curriculum to gradually build the skills and capacity necessary for students to move from structured and guided inquiry to open and completely self-directed learning.

CONTEXT

The Bachelor of Health Sciences (BHSc) program in the Cumming School of Medicine at the University of Calgary is a four-year honours undergraduate program driven by a research-intensive, inquiry-based pedagogy. Our program promotes a culture of pedagogical approaches that embraces inquiry as both a scientific process and a way of teaching. As such, the program actively supports faculty using innovative curriculum design and acts as an enabler rather than a barrier to IBL (Spronken-Smith et al., 2011). All teaching faculty are comfortable teaching through facilitation, rather than by traditional knowledge transfer, and incorporate a variety of IBL elements into their teaching practice. Additionally, a culture that explicitly embraces IBL aides with student willingness to engage in IBL and best supports student transitions to self-directed learning (Justice et al., 2007; Spronken-Smith et al., 2011).

Although IBL can range from within-class activities, inquiry courses, and whole degrees, this paper will focus on a set of required courses that comprise our IBL curriculum, known as core inquiry courses. A unique feature of our curriculum, core inquiry courses are completed in each year of study and bring students from three distinct majors (Bioinformatics, Biomedical Sciences, and Health & Society) together to participate in interdisciplinary collaboration through IBL. The focus of IBL on posing questions, gathering and analyzing data, and constructing evidence-based arguments reflects scientific inquiry and is considered a signature pedagogy of STEM education (Crippen & Archambault, 2012; Hmelo-Silver et al., 2007). Thus, IBL facilitates the achievement of our program learning outcomes (critical thinking skills, oral and written communication skills, research skills, scholarly and disciplinary literacy, collaboration, and the application of foundational skills, knowledge and methodology), and is directly aligned with the overall mission of the program to train future leaders in health research.

FRAMEWORK FOR A STAGED APPROACH

Since we aim to integrate IBL through the four years of an undergraduate program, it is essential that the curriculum be responsive to the levels of knowledge, confidence and capacity for self-directed learning of all students – from novice (Year 1) to senior (Year 4). Framing IBL as strictly unstructured and unguided learning activities has been found to be limiting in practice, detrimental to novice student learning and a barrier for IBL implementation by teaching faculty (Brown, Abell, Demir, & Schmidt, 2006; Hmelo-Silver et al., 2007; Kirschner, Sweller, & Clark, 2006). Therefore, we take a staged approach to IBL through the use of scaffolding.

Scaffolding is a process in which support and guidance from an expert (teacher) is gradually diminished, until the learner is capable of self-directed learning (Hmelo-Silver et al., 2007; Kim & Hannafin, 2011). Support from an expert or teacher allows novice learners to engage in complex tasks that are otherwise beyond their capabilities (Kim & Hannafin, 2011). Applied to IBL, scaffolding involves the teacher providing just-in-time support and appropriate resources as students move through the inquiry cycle; novice learners require more support and guidance than senior learners. Scaffolding facilitates IBL by framing it as a continuum that varies in the degree of guidance provided, degree of student independence, and the level of inquiry skills required (synthesis of existing disciplinary knowledge to independent knowledge creation) (Brown et al., 2006; Hmelo-Silver et al., 2007). Research in a variety of educational

settings has found that scaffolding is effective for developing inquiry skills and building confidence for independent learning (Hmelo-Silver et al., 2007; Kim & Hannafin, 2011).

Spronken-Smith and Walker (2010) conceptualize three levels of scaffolding for IBL: structured, guided, and open inquiry. In structured inquiry, the teacher provides an inquiry question or problem and outlines how to address it. The teacher is a co-facilitator of learning, providing regular hands-on guidance to students who are usually new to the inquiry process (Buck, Bretz, & Towns, 2008). Structured inquiry situates students in an *information frame*, which is focused on familiarizing students with existing disciplinary knowledge, in preparation for guided inquiry (Levy et al., 2010; Spronken-Smith et al., 2011). Guided inquiry provides the opportunity for student-driven inquiry questions, with moderate support as students become more independent in the inquiry process (Spronken-Smith & Walker, 2010). Open inquiry is the final scaffold and most appropriate for students who are ready for self-directed learning. At this level, students are in a *discovery frame*, in which students become co-creators of disciplinary knowledge in collaboration with teachers and disciplinary experts (Levy et al., 2010; Spronken-Smith et al., 2011). In open inquiry, students progress through the inquiry cycle with minimal support (Spronken-Smith & Walker, 2010).

Figure 1 illustrates the staged approach to IBL in the BHSc curriculum using scaffolding. The purpose of this staged approach is to gradually prepare students for self-directed learning, with students taking on increasing responsibility and developing their capacity to undertake independent research as they progress from Year 1 to graduation.

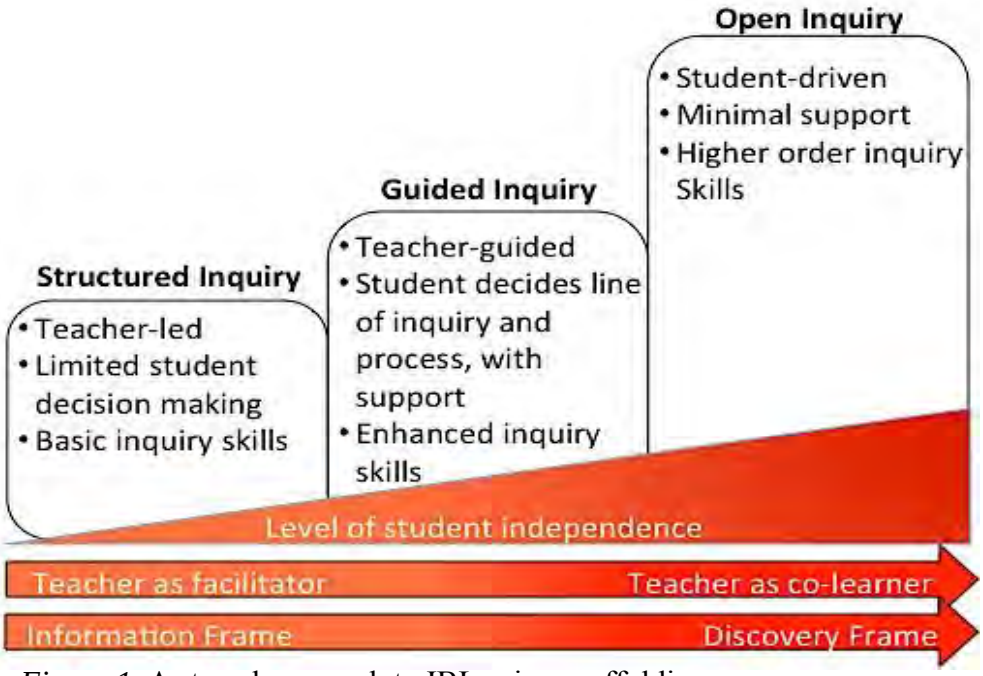

Figure 1. A staged approach to IBL using scaffolding.

IBL CURRICULUM

All BHSc students complete an IBL curriculum that spans the four years of study, regardless of their chosen health science major. The IBL curriculum is comprised of a set of core courses that apply an inquiry-based pedagogy, starting with the lowest level on the scaffold, structured inquiry, and culminating in an open inquiry honours thesis project in the fourth year.

Each course has been purposely designed to build on skills from the previous course, thus staging students' progression from novice learners to competent health researchers.

Year 1: Structured Inquiry for Novice Learners

First-year BHSc students are typically recent high school graduates, often from highly structured and guided learning settings. Consequently, students enter the program with little to no experience with the self-directed learning that typifies IBL and thus need support to adjust to new ways of learning. Additionally, first-year students often lack confidence in their intellectual capacity to be independent learners, which can lead to anxiety about their ability to engage in IBL (Levy & Petrulis, 2012; Oliver, 2007). These novice learners benefit from a structured inquiry approach to build familiarity and confidence with disciplinary knowledge and the inquiry process (Levy & Petrulis, 2012; Spronken-Smith et al., 2011).

The purpose of the first-year core inquiry course, Medical Sciences (MDSC) 203, is to build health research literacy, academic writing and presentation skills. Using both individual research papers and collaborative presentations, students explore the existing disciplinary knowledge to answer inquiry questions guided by the course instructors but applied to a topic chosen by students; for example, students may be asked to explore the biomedical mechanisms of a disease of their choosing. Through a structured inquiry approach, students have the freedom to choose a topic of personal or group interest, yet are bounded with respect to the aspects of the topic that must be explored. Students are also provided an outline for how they should approach the inquiry process through explicit modeling in class, and extensive training on how to read, interpret and synthesize scholarly literature, library research skills, academic writing, and oral presentation skills. The aim of this approach is to provide a balance between engagement with the topic and modest level of personal responsibility, which can drive motivation to pursue the inquiry process, and adequate structure to reduce anxiety and assure students that they are on the right track (Levy & Petrulis, 2012; Oliver, 2007; Spronken-Smith et al., 2011).

Writing skills are developed through three individual written assignments. These short research papers require students to address an inquiry question by searching and synthesizing the academic literature to propose solutions to, or further research about, current health issues. Since this is often the first time that students are held to university-level writing standards, this is a difficult task for many. To facilitate the development of these skills and to reduce anxiety, a rubric is provided and students submit a draft of their first paper for extensive formative feedback, which they can then apply to a final version that is graded. Students are also provided extensive feedback on the second and third papers to continue to develop their writing skills.

MDSC 203 also focuses on collaboration and oral communication skills, two important program learning outcomes. Students work in preselected interdisciplinary groups of 6-8 students to address an inquiry question applied to a disease topic chosen by the group and present their findings in a formal academic presentation. Group work is often incorporated into IBL, especially for novice learners, because collaborative learning has been found to improve inquiry skills and to provide social support through the inquiry process (Levy et al., 2010). However, peer collaboration is not without its challenges; thus, support for the group work process is also important (Levy & Petrulis, 2012). Groups are mentored by a preceptor, a faculty member or a teaching assistant, who guides the group through the inquiry process and helps students manage some of the pitfalls of group work. Groups meet once per week during scheduled class time, with the group preceptor present during each session. Designated class time facilitates peer

collaboration and helps to reduce the workload associated with IBL for students, especially as they adjust to the general workload of the post-secondary setting (Spronken-Smith et al., 2011).

Applying a structured inquiry approach, MDSC 203 develops students' basic inquiry skills, including searching academic literature, synthesizing information, and proposing solutions within an information frame. The role of the teacher as facilitator is central to building students' confidence for more independent work later in the program. This is achieved by providing ongoing feedback about academic writing, oral presentations, and the inquiry process, and a supportive environment for developing self-directed learning (Spronken-Smith et al., 2011).

Year 2: Guided Inquiry

MDSC 308 is a full-year course designed to develop interdisciplinary collaboration skills. This core inquiry course serves to enhance inquiry skills using a guided inquiry approach, where the balance shifts to student-driven inquiry questions and greater learner independence than in the first year. To achieve this, students work in pre-selected interdisciplinary groups of 4-5 individuals to complete two IBL projects. The first project requires students to create a health promotion poster for a student-identified audience, the second project entails a group presentation and an academic report that examines the health needs of a student-selected Canadian community and proposes evidence-based and contextually appropriate disease prevention and health promotion solutions. For both projects, all groups create similar assessment products but the topics vary widely since students are given the freedom to choose their health topic of interest and their areas of inquiry. The intellectual freedom and absence of a "right" answer can make students uneasy, so this is an area where guidance is provided. Group check-ins during scheduled class time (two per semester) allow the instructor to provide feedback on the chosen inquiry questions and follow up on group progress. Rubrics provide guidelines for aspects that the inquiry might consider, focused on synthesis and application rather than on specific content. Modeling in class is also helpful in this regard. For example, students participate in an interactive session about health promotion, where they critically analyze existing health promotion campaigns, and are provided with the basics of health communication techniques as they may apply to designing a poster or a community presentation. Peer and self-evaluations of collaboration among group members, which contribute to the final grade, are also important for increasing self-regulation, reflection. and responsibility among students (Topping, 1998). The role of the teacher, in this case, shifts away from hands-on facilitator to supportive mentor. Fostering independence is key; students should feel challenged and even a little uncertain, yet feel that support is available when needed so that they can confidently advance towards a discovery frame of learning in preparation for open inquiry (Levy et al., 2010; Spronken-Smith et al., 2011). Similar to other educators, we have found these strategies to be effective for supporting IBL and for striking a balance between just the right amount of structure and self-directed learning (Spronken-Smith et al., 2011).

MDSC 308 enhances the communication and collaboration skills developed in MDSC 203 by increasing the level of student independence and shifting the focus to higher-order inquiry skills, including analysis, evaluation and reflection. This stage of guided inquiry prepares students for a transition into open inquiry.

Year 3: Transition to Open Inquiry

By the third year, BHSc students have experience with the inquiry process and have acquired foundational disciplinary knowledge. However, not all have engaged with health research, which could disadvantage some students in the honours thesis projects to be completed in the fourth year. Therefore, the third year of the IBL curriculum is focused on building technical research skills, supporting independent exploration of the research process and enhancing confidence in independent learning.

In contrast to previous core inquiry courses, students are separated into two discipline-specific inquiry courses, MDSC 408 (for Bioinformatics and biomedical Sciences majors) or HSOC 408 (for Health & Society majors), so that students can master the research methods and techniques appropriate to their major. Regardless, both inquiry courses provide an opportunity for students to explore a student-driven research question and to engage in the research process, which closely follows the inquiry cycle. For example, HSOC 408 students complete a 4-month independent research practicum in which they co-design a health research question and complete the research process to answer it, under the supervision of a course-approved researcher. MDSC 408 students develop a biomedical research proposal to answer a student-generated research question as the primary course assessment activity. In both courses, students work independently, applying their disciplinary knowledge in a discovery frame to produce novel insights about health. Guidance and support are still key components of these courses – students meet regularly with course instructors and/or research supervisors and receive formal ongoing feedback. This approach facilitates a transition to truly open inquiry, where students complete an independent thesis project. It also identifies students who are not yet ready for open inquiry and who may require additional knowledge and skills to prepare for fully self-directed learning.

Year 4: Honours Thesis

All BHSc students complete an undergraduate honours thesis, an independent research project that is entirely student-driven and completed in collaboration with a faculty researcher. Students self-select the faculty researcher with whom they wish to work, define their own research question and engage in independent research to answer that question. This is an open inquiry activity, with students functioning in a self-directed discovery frame and exercising self-motivation, independence, and higher-order inquiry skills including critical analysis, reflection, evaluation, and knowledge creation (Buck et al., 2008; Spronken-Smith & Walker, 2010). The thesis culminates with the submission of a written thesis, which is subsequently orally defended in front of a panel of faculty members.

Although the thesis is an independent undertaking, BHSc honours thesis students are enrolled in MDSC 508, the final core inquiry course. MDSC 508 is coordinated by two faculty members and one graduate teaching assistant, who are readily available to support students. Typical supports provided are proposal and thesis writing workshops, a research ethics refresher, and a session to prepare for the thesis oral exam. Support is also provided on an individual and as-needed basis to students who struggle with time management, motivation or face relationship difficulties with research collaborators. In addition, the role of faculty research collaborators is to mentor and support students throughout their individual research project so that students may receive adequate and appropriate support from many sources.

The honours thesis is the capstone of the BHSc program. It is an opportunity for students to demonstrate their achievement of the program learning outcomes and their capacity for

independent health research. The staged approach to the BHSc IBL curriculum ensures that students are well equipped to complete this capstone experience successfully.

CONCLUSION

In this paper, we have outlined a framework for scaffolding IBL, which can be used when designing a student-centered, inquiry-based curriculum. Our staged approach works to balance structure and independence according to student level of knowledge and capacity for self-directed learning. Gradually reducing guidance as students increase their knowledge, confidence, and inquiry skills helps to mitigate student anxiety and improves engagement with IBL (Hmelo-Silver et al., 2007; Kirschner et al., 2006). The BHSc IBL curriculum is a work in progress and we continue to refine our approach, improving opportunities for student reflection, mitigating challenges with group work and using existing classrooms as spaces for collaborative inquiry. However, our staged approach to IBL makes students the drivers of their learning in a supportive environment and ultimately supports our mission of training future health research leaders.

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REFERENCES

Brown, P. L., Abell, S. K., Demir, A., & Schmidt, F. J. (2006). College science teachers' views of classroom inquiry. *Science Education, 90*(5), 784-802.

Buck, L. B., Bretz, S. L., & Towns, M. H. (2008). Characterizing the level of inquiry in the undergraduate laboratory. *Journal of College Science Teaching, 38*(1), 52-58.

Crippen, K. J., & Archambault, L. (2012). Scaffolded inquiry-based instruction with technology: A signature pedagogy for stem education. *Computers in the Schools, 29*(1-2), 157-173.

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006). *Educational Psychologist, 42*(2), 99-107.

Justice, C., Rice, J., Warry, W., Inglis, S., Miller, S., & Sammon, S. (2007). Inquiry in higher education: Reflections and directions on course design and teaching methods. *Innovative Higher Education, 31*(4), 201-214.

Kim, M. C., & Hannafin, M. J. (2011). Scaffolding problem solving in technology-enhanced learning environments (teles): Bridging research and theory with practice. *Computers & Education, 56*(2), 403-417.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*(2), 75-86.

Levy, P., Little, S., McKinney, P., Nibbs, A., & Wood, J. (2010). *The Sheffield Companion to Inquiry-based Learning*. Retrieved from Sheffield, UK: https://www.sheffield.ac.uk/ibl/resources/sheffieldcompanion

Levy, P., & Petrulis, R. (2012). How do first-year university students experience inquiry and research, and what are the implications for the practice of inquiry-based learning? *Studies in Higher Education, 37*(1), 85-101.

Oliver, R. (2007). Exploring an inquiry-based learning approach with first-year students in a large undergraduate class. *Innovations in Education and Teaching International, 44*(1), 3-15.

Spronken-Smith, R., Walker, R., Batchelor, J., O'Steen, B., & Angelo, T. (2011). Enablers and constraints to the use of inquiry-based learning in undergraduate education. *Teaching in Higher Education, 16*(1), 15-28.

Spronken-Smith, R., & Walker, R. (2010). Can inquiry-based learning strengthen the links between teaching and disciplinary research? *Studies in Higher Education, 35*(6), 723-740.

Topping, K. (1998). Peer assessment between students in colleges and universities. *Review of Educational Research, 68*(3), 249-276.