

Embedding sustainability learning pathways across the university

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The University of British Columbia's (UBC) long-term vision is to embed sustainability in all of its undergraduate teaching programs. The University has described four student sustainability attributes — Holistic Systems Thinking, Sustainability Knowledge, Awareness and Integration, and Acting for Positive Change — to help guide academic units to develop sustainability learning pathways. These pathways are loosely defined as any combination of curricular experiences that, when combined, equip undergraduate students with a firm grounding in the four attributes in the context of sustainability. Amongst the early adoption of the attributes has been their application at the course level in a pilot introductory course, 'SUST 101', and their use in designing a sustainability pathway within the Faculty of Science. In this paper we describe the structures developed at UBC to support and enable sustainability education, summarize the curriculum framework for sustainability at UBC, and present curriculum examples that employ the University's sustainability education framework.

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Introduction

Institutions of higher education play a vital role in addressing contemporary sustainability challenges and opportunities, as their teaching, research and community engagement functions can impact global environmental issues and influence societal change. By educating future leaders and community members, conducting research,

and demonstrating best practices, universities can have a profound impact on the state of our current and future society [1,2]. The idea of the sustainable university [3], and particularly the transformative orientation of the institution towards sustainability, implies that the university's vision, values and practices have been re-oriented to reflect a tight framing around specific conceptualizations and expressions of sustainability [4**].

The University of British Columbia (UBC) in Vancouver, Canada has, since its inception in 1910, been actively involved in global discussions around sustainability [5*]. In 1997, UBC adopted a sustainable development policy encouraging sustainable practices in all of its actions and mandating a leadership role in instilling sustainable development values in its graduates [6]. The strategic plan for the University expresses a commitment to an exceptional learning environment that advances a civil and sustainable society [7] and UBC's Sustainability Academic Strategy, formally approved in 2010, actively promotes sustainability as 'the emergent property of a societal conversation about the kind of world we want to live in, informed by some understanding of the ecological, social, and economic consequences of different courses of actions' [8]. In that document, UBC articulated the vision that all its students should have access to an education in sustainability via a sustainability learning pathway [8]. In 2014, UBC approved a 20 Year Sustainability Strategy, which covered a wide spectrum of university activities including an enhanced focus on developing research within and outside the University and involving strategic partnerships with industry and government, a renewed focus on University operations and infrastructure through the lens of the living lab, and within teaching and learning, a renewed institutional commitment to embed sustainability learning across all undergraduate teaching programs by 2035 [9].

The goal to embed sustainability in all undergraduate teaching programs mirrors UBC's view that sustainability, as a societal imperative and normative concept about the kind of world we want to live in, is fundamentally applicable to all students and all disciplines. That is, in contrast to a prevalent discourse on 'green jobs', the UBC view is that all occupations have sustainability content, and that sustainability knowledge is thus potentially useful to all graduates. The pathways vision is a strategically and structurally different approach from building new schools or faculties that offer interdisciplinary

sustainability curriculum as separate degree programs (e.g., [10]), or innovative programs that are only available to a select group of students, though these are, of course, not mutually exclusive activities. The pathways approach posits that all students require access to equipping themselves with the competencies and capacities that enable them to contribute to the co-creation of a sustainable future, and so envisions providing sustainability education for students in all faculties and departments on campus [11]. The objectives of this paper are to first, outline UBC's structure that supports and enables sustainability education across the university; second, summarize the curriculum framework for sustainability at UBC; and third, present undergraduate curriculum examples that employ the UBC sustainability education framework.

University-wide initiative for sustainability

The UBC Sustainability Initiative (USI) was created in 2010 in response to the adoption by UBC of the Sustainability Academic Strategy, a mid-level plan to support UBC's strategic commitment to sustainability [12*]. The USI's teaching and learning mandate is twofold: first, to be a hub for academic sustainability resources and activities on campus (operational), and second, to catalyze and coordinate key university stakeholders to determine how to achieve the learning pathways goal (academic). The USI Faculty Fellows Program was launched in 2010 to support this academic mandate. The program brings together faculty leaders in sustainability education from across campus to act as a think tank to guide UBC towards meeting its academic sustainability goals. Fellows are UBC faculty who apply to work with USI for one or two years. The group of 6–8 fellows meet regularly, about every 2–3 weeks throughout the academic year, to discuss emerging issues and write guiding documents for the UBC community on sustainability education. While the program was additional to the faculty members' standard duties and faculty members received no teaching buyout for the program, they were provided with additional resources which were used for a variety of purposes, such as research assistance. Fellows were also encouraged to document their experiences in both peer reviewed and non-peer reviewed literature. As a result, the USI program, while designed to enhance a fellow's career path at UBC, was not explicitly recognized in promotion and tenure procedures.

Curriculum framework for sustainability

The inaugural cohort of fellows decided that the crucial first step in developing more extensive sustainability programming at UBC was to create a competence or outcomes-oriented framework as a high-level expression of sustainability education at the university. This approach adopts the perspective that education should focus on student outputs, rather than traditional didactic approaches that focus on teacher inputs, and that

sustainability education should strive to equip students with the knowledge, skills and abilities that enable them to understand and resolve complex sustainability problems and to become change agents [13**,14]. The UBC framework also implicitly acknowledges that approaches developed for sustainability education should have a flexible, adaptable character to ensure relevance in a variety of settings [15]. This is particularly important as the UBC sustainability attributes and pathways concepts were designed to guide the integration of sustainability into *all* undergraduate teaching programs across a large and diverse academic institution. For success, it is critical that faculty curriculum developers see a clear and significant connection between the student attributes expressed in the sustainability framework and their discipline, and are empowered to create curricula that work for their particular disciplinary context.

The UBC sustainability education framework that resulted from this initial work of the Fellows describes four key student sustainability attributes intended to guide the design of pathway and course-level learning outcomes (Table 1, [16]). They are the desired attributes of graduating students who have followed a sustainability pathway within the University.

The first attribute, *Holistic Systems Thinking* emphasizes that seemingly separate activities, from many interdependent social, ecological and economic systems, form one complex global system [17,18]; acknowledges the interdependent, inter-relational, and contextual aspects of phenomena; and applies an integrated, inclusive mindset to problem solving. It considers the assumptions, knowledge, means and methods to see, articulate and quantitatively and qualitatively measure and understand how human and natural systems work and interact. Such thinking is repeatedly cited as a key competency in sustainability, with associated learning outcomes such as students gaining an increased understanding of complexity theories [18], students acquiring an increased ability to identify connections between multiple scales [19], and students having the ability to analyze complex systems across different domains (society, environment, economy) and across different scales (local to global) [14].

The *Sustainability Knowledge* attribute recognizes that a student's area of academic inquiry informs their interests and values related to sustainability. It posits that students need to not only have a working knowledge of fundamental, overarching concepts central to sustainability (e.g., sustainability models and paradigms), but also must understand contemporary sustainability issues related to their field of study. Associated learning outcomes could be that students are able to demonstrate and contrast three and four component sustainability models and analyze their use when examining issues such as climate change or biodiversity loss, or those students are able to

Table 1

A summary of UBC's sustainability education framework, outlining the four student sustainability attributes and associated example learning outcomes

Student sustainability attributes			
Holistic Systems Thinking Everything is connected	Sustainability Knowledge Understand the context, know the challenges	Awareness and Integration Connect what I know with what you know	Acting for Positive Change Contribute to co-creating a better future
Sustainability depends on, and aspires to, a purposeful, equitable and harmonious integration of human and natural systems. Holistic, ecological, or synergistic systems thinking (aka a 'joined-up mindset') requires students to acquire the means and methods to see, articulate and qualitatively and quantitatively measure how human and natural systems work and interact	Sustainability depends on comprehensive knowledge within one's area of study, and an understanding of contemporary sustainability issues (particularly those which relate to their own area of study). Sustainability knowledge also requires students to gain proficiency in the underlying ideas and principles of sustainability, and in the evaluation of different sustainability models and paradigms	Sustainability depends on a broad range of inter-disciplinary, cross-disciplinary and trans-disciplinary approaches to allow for the emergence of new domains of knowledge equal to the task of addressing global sustainability issues. Awareness and Integration requires students to think and act in new ways to solve complex, integrative problems through collaboration between disciplines	Sustainability depends on change agents who have the skills, persistence, and resilience to contribute to the emergence of healthy ecosystems, social systems, and economies. Acting for Positive Change requires students engage others and implement or contribute to positive change
<i>Example learning outcomes:</i> 1. Demonstrate a capacity to appreciate that all actions have consequences within, between and among systems 2. Understand how tipping points, interdependencies, feedback loops, and emergent properties impact a variety of social, economic and ecological systems 3. Engage in dynamic conversation about different types of systems and processes (e.g., the food web, globalization)	<i>Example learning outcome:</i> 1. Compare and contrast three and four component sustainability models, and assess their utility when examining issues such as climate change or biodiversity loss 2. Demonstrate an understanding of how social equity contributes to global sustainability 3. Display knowledge of how economic theory and resource equity contribute to sustainability	<i>Example learning outcome:</i> 1. Appreciate that sustainability demands participation from all disciplines and contributions from society 2. Empathize with intercultural perspectives and recognize their value to illuminate environmental and social issues 3. Demonstrate the ability to weigh multiple perspectives	<i>Example learning outcome:</i> 1. Engage in self-assessment, self-reflection, and analysis and have a strong awareness of one's own values and how they inform one's ways of seeing (i.e., paradigmatic awareness) 2. Use relevant theories of societal and institutional change to identify when and where to direct energy and actions towards a targeted outcome 3. Work collaboratively with others to creatively solve a community focused problem

make connections between their own domain of study and sustainability concepts like the triple bottom line.

Concomitantly, the *Awareness and Integration* attribute explicitly acknowledges the limitations of a reductionist framework — which is mirrored in the disciplinary structure of contemporary universities — in solving the class of problems humanity currently faces [20]. Sustainability issues are often characterized by complexity and uncertainty and cannot be understood adequately through single disciplines, although each has a contribution to make [21]. Since the disciplinary fragmentation of knowledge can lead to un-sustainability when applied to a joined-up world [22,23], students need to be able to cross disciplinary boundaries and integrate information from multiple disciplines. Skills that foster communication and work across disciplines are critical to achieve a mutual understanding of ideas, mind sets, philosophical principles, frames, methodologies and cognitive styles traditionally confined to single disciplines. The emergence of

new domains of knowledge equal to the task of addressing global sustainability issues in all their dimensions requires a broad range of inter-disciplinary, cross-disciplinary and trans-disciplinary approaches. Learning outcomes supportive of this attribute will stress that students are aware of their personal patterns and process of constructing knowledge, and that students appreciate that sustainability demands participation from all disciplines and contributions from society.

The final attribute, *Acting for Positive Change*, requires that a student graduating from UBC with a background in sustainability must be able to engage others and implement or contribute to positive change. This acknowledges that at its core, sustainability education is a process through which students work towards becoming effective change agents who have the skills, persistence, and resilience to contribute to the emergence of healthy ecosystems, social systems, and economies [20,24]. Community-based, participatory and teamwork methods

develop engagement skills such as mediation and conflict resolution [19,25], while change agency and leadership also require students to understand relevant theories of societal and institutional change so they can make informed decisions on when, and where, to direct their energy and actions (i.e., ‘strategic competence’ *sensu* [14]). Community-based experiential learning approaches are being incorporated into sustainability pathways at UBC to ensure student teams collaborate with stakeholders both on and beyond campus on sustainability problems and opportunities. For example, the UBC’s SEEDS (Social Ecological Economic Development Studies) [28] program provides students with real-world sustainability experience, skills and knowledge while they earn course-based credit. Students work collaboratively, either within a class, or more often in small groups, or individually, with faculty and staff to develop and implement projects that build on the theme of campus as a living laboratory to address campus sustainability challenges, many of which have been implemented or have influenced decision making.

Sustainability pathways

The sustainability attributes described in the previous section provide an outcomes-based framework to guide the development of sustainability learning pathways. A central element of UBC’s approach to sustainability education is a high degree of flexibility with respect to the operational implementation of such pathways. Although UBC provides suggestions for how to build an effective and comprehensive pathway [16], such as the inclusion of two book-end courses (introductory course and capstone course) and learning outside the classroom via real world sustainability projects, curriculum developers are encouraged and supported by the University to develop programming that works for their particular context. This approach recognizes that sustainability can be operationally integrated into a curriculum at the discipline or broader scale (i.e., within or between Faculties), and can be embedded by leveraging existing structures or by creating new structures [26]. As anticipated, pathways currently under development at UBC are adopting different models, such as creating new courses to fill key gaps, embedding sustainability into existing courses and degree programs, and developing sustainability-specific streams and minors. Due to the varied models of implementation, the assessment process for pathways is likely to be tailored to each faculty offering the pathway, as each faculty has its own responsibilities with respect to curriculum approval, implementation and assessment. It is likely that the different components of the pathways will each have their own assessment criteria which can then be carried forward to an overall recognition of pathway participation.

Curriculum examples

The examples below outline the adoption of the attributes framework and pathways goal via different

initiatives and academic groups at UBC. Key insights, challenges and outcomes are discussed.

‘SUST 101’ pilot course

To initiate the development of sustainability learning pathways, the USI and its Fellows analyzed the complete range of sustainability-related curriculum offerings at UBC in 2010–2011. This resulted in the identification of over 450 sustainability-related courses, and highlighted that a key deficiency in the curriculum was the lack of entry-level courses focused on sustainability broad enough to touch on all disciplines and available to all students in the first year of their program [5]. Since an introductory sustainability course had been identified as a key component of a pathway [16], the USI Fellows decided to develop and teach an entry level, interdisciplinary sustainability course (‘SUST 101’), which would be available to all students across the university, regardless of faculty or year level. The course was offered in January 2012 and was taken by students from first through to fourth year, and from 5 different faculties covering a wide range of disciplinary interests and associations. To enable piloting the course within a short timeframe, and to meet the requirement that courses must be situated within an academic unit, the Fellows agreed to offer the course under course codes associated with their home faculties. This resulted in the course being offered in five faculties simultaneously under five different course codes. The long-term intent was to find an administrative home for the course which reflected the interdisciplinary focus of the course and the diverse teaching team.

The attributes framework was used to design course content and delivery, and informed the course goals, learning outcomes and assessment. Course successes included the development of a strong sense of community among the participants including both students and the teaching team and fostered a community identity that proved to be motivational for students. Students not only enjoyed interacting with peers from different faculties and programs, but formed mentor–mentee relationships, and created an online information and support network.

Other successes included the development of meaningful assignments related to the attributes, and the effective implementation of a robust team teaching dynamic that fostered lively discussion across the disciplines. The most significant challenges with the course were administrative issues related to coordinating the teaching team (6 faculty members), and issues stemming from the course lacking an administrative home.

A key lesson learned, which critically helped the USI refine how best to support movement towards UBC’s pathways goal, is that sustainability curricula are best offered within the existing university faculty structure with a collaborative and inclusive mindset. While SUST

101 was very successful in terms of the pedagogical goals laid out for the course, it became apparent that it would not be possible to implement it as a large first year course at UBC due to the administrative and logistical difficulties of implementing and running such a course. Put another way, the disadvantages of having such courses housed within a single faculty (with their acknowledged discipline biases) are currently outweighed by the advantages of the course being offered with standard faculty support and supervision.

This led to a change in approach, and subsequent efforts at UBC to address the gap of entry-level sustainability courses have taken two directions. First, we are working with existing large first year courses in multiple Faculties to inject sustainability content into these courses. This has several advantages: no new courses are required, virtually all UBC students take one or more of these courses, and the connections of sustainability to different disciplines and programs are made explicit. Currently we are working to embed sustainability content in first year courses in Math, Engineering, Geography, Biology, Chemistry and Sociology. Second, at the second year level (the year in which most students enter their program major) we are supporting the development of introductory courses within individual faculties — for example, the Faculty of Science developed an Introduction to Sustainability course that was designed and developed by an interdisciplinary faculty team and is open to all students (launched in January, 2013). As the first year courses start to embed sustainability content, such courses can build on that content, and provide a tailored entry into the specific focus of the major program, and to a suite of sustainability electives and community service courses.

Sustainability pathway in the Faculty of Science

The Biology Program (Departments of Botany and Zoology) is the first adopter of the pathway concept at UBC. The mission of this sustainability pathway is to provide an opportunity for students to pursue a sustainability focus in conjunction with their development as biologists (Shona Ellis, pers. commun.). The biology approach is to integrate sustainability within the existing biology degree program, so students do not need to take any additional courses and are able to complete the pathway by simply selecting the appropriate electives. This pathway has five main components: first, fundamentals course; second, real world experience; third, selection of sustainability electives; fourth, capstone course, and fifth, sustainability learning community (SLC) (Figure 1). This pathway structure was adopted more broadly in the Faculty of Science and current development is at the faculty level with engagement of seven faculties across campus.

The Faculty of Science pathway is grounded in the UBC sustainability attributes framework and the three pillar model of sustainability (environment, society, economics),

Figure 1

YR 4	Capstone/Leadership Course		Sustainability Learning Community
YR 3/4	Sustainability Electives (courses vetted for sustainability attributes)	Real world experience (e.g., CSL Co-op, etc.)	
YR 1/2	Introductory Course (e.g., SCIE 220)		
YR 1	First year courses with sustainability embedded (e.g., CHEM 100, SOCI 100, MATH 102, PSYC 101 etc.)		

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UBC sustainability pathway in the faculty of science. Bolded text indicates the official pathway, which starts in year 1 or 2 with an introductory sustainability course. First year courses with sustainability embedded are intended to raise student interest in sustainability and inspire students to pursue a pathway.

both of which guide the development of pathway learning outcomes, the creation of new courses, and the identification of appropriate electives from existing courses. Currently two new ‘book-end’ courses have been developed: an entry-level sustainability course (SCIE 220, Introduction to Sustainability), and a fourth year sustainability capstone course currently being piloted (Sustainability for Community and the World). This interdisciplinary course will be administered by the Faculties of Science and Arts.

A key contribution from biology and the Faculty of Science is the concept of a SLC, whose purpose is to provide all pathway students a place to exchange ideas and explore sustainability across the disciplines and reflect on their pathway experience. The motivation behind the SLC is to connect all pathway students across years of study and disciplines, and offer a space (physical and virtual) for students to achieve outcomes associated with the ‘awareness and integration’ attribute. This concept is being promoted to curriculum developers of other pathways, and to date has wide-ranging buy-in.

USI pathway support

To further support the attainment of UBC’s sustainability pathways vision, the USI launched a Pathways Seed Grant Program in 2014 to support faculty champions to lead curriculum efforts within their respective academic units. Pathways are now under development in the Faculty of Applied Science (whole faculty), the Faculty of Science (Departments of Earth Ocean and Atmospheric Science & Geology), and the Faculty of Arts (Geography). Each unit is developing learning outcomes for the four attributes and are considering different operational pathway models, which reinforces the view that flexibility and departmental/faculty ownership seems to be a key to

success. For example, the Faculty of Applied Science is in the early stages of developing their specific degree-level learning outcomes that support the sustainability attributes, and their next steps are to create activities and assessments aimed at filling sustainability knowledge gaps, and addressing first year student misconceptions about engineering and sustainability [27]. Parallel processes are underway in the other academic units supported by Pathway grants. A revised Fellows program is currently being piloted by the USI to help support curriculum developers create pathways.

The way forward

UBC has adopted a whole-institution commitment to sustainability, reflected in its policies, plans and strategies. Its academic sustainability aspirations are supported and bolstered by the USI, a strategic management group that integrates and enables UBC's numerous sustainability initiatives across all branches of the University. The first five years of experience with the USI reveal that from a curriculum perspective, it is highly valuable to be outside of the faculty structure to see the big picture and develop effective cross-faculty links and synergies. In order to effectively implement change, however, curriculum transformation needs to be undertaken within the faculty structure. As a result, the USI can be an effective think tank and can create useful frameworks and ideas for discussion, but cannot develop and deliver curricula.

Key roles carried out by the USI include coordinating the faculty Fellows program, enabling connections among faculty across disciplines, supporting pathway development by curating the range of university-wide sustainability courses and programs, and catalyzing (through funding) changes at the course and program level. A structure like the USI can also respond to changing needs within the institution, as evidenced by its shift from high-level framing and direction-setting to supporting the implementation of pathways. An additional benefit is USI's ability to house institutional knowledge about the trajectory of advancing sustainability education on campus, and related challenges and lessons learned.

UBC has just embarked on the execution of its ambitious, long-term goal to embed sustainability in all of its undergraduate teaching programs so that all students will have access to an education in sustainability. The framework of the four student sustainability attributes has yet to be tested, but early indications are that Holistic Systems Thinking, Sustainability Knowledge, Awareness and Integration and Acting for Positive Change resonate with a variety of disciplines and contexts, and that flexibility in pathway implementation is key to success. The next 5 years will reveal if the catalytic and supportive role of the USI is effective, and this learning will benefit other university institutions seeking to embed sustainability across the full range of the undergraduate curriculum.

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