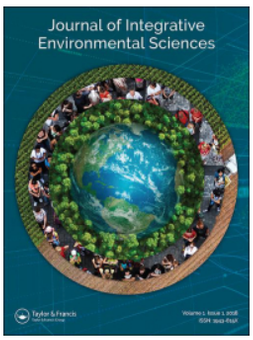

Taylor & Francis
Taylor & Francis Group

Journal of Integrative Environmental Sciences

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/nens20

Reaching the Rest: Embedding Sustainability in Undergraduate Student Learning

John Robinson, Ayako Ariga, Sean Cameron & Ryan Wang

To cite this article: John Robinson, Ayako Ariga, Sean Cameron & Ryan Wang (2022) Reaching the Rest: Embedding Sustainability in Undergraduate Student Learning, Journal of Integrative Environmental Sciences, 19:1, 171-187, DOI: 10.1080/1943815X.2022.2131829

To link to this article: https://doi.org/10.1080/1943815X.2022.2131829

Published online: 25 Oct 2022.

JOURNAL OF INTEGRATIVE ENVIRONMENTAL SCIENCES
2022, VOL. 19, NO. 1, 171–187
https://doi.org/10.1080/1943815X.2022.2131829

Taylor & Francis
Taylor & Francis Group

RESEARCH ARTICLE

OPEN ACCESS Check for updates

Reaching the Rest: Embedding Sustainability in Undergraduate Student Learning

John Robinson, Ayako Ariga, Sean Cameron and Ryan Wang

President's Advisory Committee on the Environment, Climate Change, and Sustainability (CECCS), University of Toronto, Toronto, Ontario, Canada

ABSTRACT

There exists a substantial literature on sustainability pedagogy. Much of it addresses individual courses, sustainability programs, or the learning competencies that are encouraged. The implicit focus is on students who have chosen to specialize on sustainability topics by obtaining a degree in programs such as , sustainability management, environmental science or studies. More recently, there has been emerging literature calling for embedding sustainability into entire university curricula as sustainability becomes a more prominent issue for higher education institutions. Four key themes have emerged in this literature that are relevant to the goal of developing sustainability pedagogy relevant to all students: (i) the organizational framework for the content of sustainability pedagogy, (ii) the conceptualisation and teaching of inter-transdisciplinarity, (iii) the relative merits of compulsory or voluntary sustainability programming, and (iv) the role of course inventories. In this paper, we examine the University of Toronto's introduction of a new model of sustainability learning and evaluate it against the themes and recommendations found in the literature. This model aims to establish university-wide sustainability learning trajectories, called Sustainability Pathways whose novelty is in its offer to reach many more students than other approaches. The key themes emerging from the literature will serve as a basis for program evaluation. It is found that the Pathways program does embody some of these themes but that further development would be desirable. The program and the course inventories at its foundation will go through periodic evaluation to assess progress on program goals and objectives.

ARTICLE HISTORY
Received 25 Jan 2022
Revised 05 Sep 2022
Accepted 20 Sep 2022

KEYWORDS
Higher education; sustainability education; sustainability pedagogy; SDGs; interdisciplinary; transdisciplinary; sustainability competencies

Introduction

The need for transformative forms of integrative sustainability education, either at the whole system level or in terms of individual courses, has received much attention. However, most of the literature on sustainability pedagogy has focussed on teaching sustainability to students who have chosen sustainability as their major or program (Filho et al., 2018; Schrand et al. 2013; Wiek et al. 2014; Wright et al. 2015; Jarchow et al. 2017), which targets only a very small number of students. At the University of Toronto (U of T), for example, enrolment in sustainability-related programs accounted for just 4% of the entire undergraduate student body in the fall of 2021.

CONTACT Ayako Ariga ayako.ariga@utoronto.ca President's Advisory Committee on the Environment, Climate Change, and Sustainability (CECCS), University of Toronto, Toronto, Canada

To reach the remaining 96%, the President's Advisory Committee on the Environment, Climate Change, and Sustainability (CECCS), is developing the Sustainability Pathways program which clusters courses and co-curricular activities with a common theme of sustainability to allow students to explore sustainability from various disciplinary, methodological, and practical perspectives. The program aims to develop and offer both curricular and co-curricular pathways to provide all undergraduate students with the opportunity to incorporate sustainability learning into their program, regardless of the degree program that they are in, and to develop cross-cutting interdisciplinary skills.

Students have consistently asked not only to gain the knowledge and skills needed to address sustainability challenges but also to take part in determining how that curriculum is taught and delivered. With significant input from students, the Sustainability Pathways Program goes beyond individual courses to include co-curricular activities outside the formal curriculum.

This paper will begin by discussing some of the key themes emerging in the literature on sustainability pedagogy, having to do with core competencies, inter- and transdisciplinarity and mandatory courses. Following this the attributes, components and processes of creating the Sustainability Pathways program are discussed, with particular attention paid to the tensions that were identified in the literature and that also appeared during the programming process. This paper concludes with an evaluation of the Sustainability Pathways program based on the findings of the literature review.

Sustainability Pedagogy

There is a substantial and growing literature on sustainability pedagogy (Wiek and Kay 2015; Singer-Brodowski et al. 2018; Zamora-Polo & Sanchez-Martin, 2019). Although much of the literature is focused on the design and application of sustainability-related courses and programs (Schrand et al. 2013; Mintz and Tal 2014; Wiek et al. 2014; Jarchow et al. 2017; Kishita et al. 2018), there has been emerging literature calling for embedding sustainability into entire university curricula as sustainability becomes a more prominent issue for higher education institutions (HEIs) (Marcus et al. 2015; Wright et al. 2015; Leal Filho et al. 2018; Pompeii et al. 2019).

Four key themes have emerged in this literature that are relevant to the goal of developing sustainability pedagogy relevant to all students at the university: (i) what the organizational framework should be for the content of sustainability pedagogy, (ii) how interdisciplinarity and transdisciplinarity should be conceptualized and taught, (iii) the relative merits of compulsory or voluntary sustainability programming, and (iv) the role of course inventories. Each will be discussed in turn, followed by a general discussion of the challenges involved in developing new sustainability pedagogy aimed at the entire student body.

SDG framework vs core competencies concept

There has been considerable debate over the development of a framework for teaching sustainability, much of it focussed on the development of sustainability competencies (Singer-Brodowski et al. 2018; Diaz-Iso et al., 2019; Brundiers et al. 2020; Sisto et al. 2020). Much of the literature consists of varying lists of competencies and implementation

methods without a consistent framework (Schrand et al. 2013; Wiek and Kay 2015; Díaz-Iso et al. 2019; Miñano Rubio et al. 2019). Thus, there have been many attempts towards establishing a common framework for competencies (Wiek et al. 2011; Díaz-Iso et al. 2019; Miñano Rubio et al. 2019; Brundiers et al. 2020). The most commonly adopted framework for a core competencies approach was introduced by (Wiek and colleagues in 2011), later updated in 2016. This framework calls for three separate categories of competencies, divided into attitudes, skills, and knowledge, and outlines five specific competencies: systems thinking competency, anticipatory competency, normative competency, strategic competency, and interpersonal competency (Wiek et al. 2011). Two additional competencies were later suggested by Brundiers and colleagues to address the growing call for actionable solutions from sustainability courses and programs: (1) an intrapersonal competency, and (2) an implementation competency (Brundiers et al. 2020). This interlinkage between the competencies lends itself to the development of skill-based core competencies specifically related to sustainability which are to be developed alongside normal competencies often seen in higher education, such as collaboration and research and analysis skills (Wiek et al. 2011). Other frameworks have suggested additional discipline-specific competencies (Bianchi, 2020) and the ability to engage with interdisciplinary and transdisciplinary learning (Evans 2019; Roy et al. 2020; SDSN 2020). Furthermore, there is agreement amongst most frameworks that competencies should be tailored to fit the local stakeholder situation and integrated with input from the student and mentorship from the instructor when mapping out courses and program design (Brundiers & Wiek., 2013; Wiek and Kay 2015; Díaz-Iso et al. 2019; Brundiers et al. 2020). However, the dissonance between the importance of contextualizing any sustainability curriculum and having a universally agreed upon framework has yet to be resolved (Wiek et al. 2011; Díaz-Iso et al. 2019; Brundiers et al. 2020).

More recently, there has been the emergence of literature proposing approaches to sustainability pedagogy based on the United Nations Sustainable Development Goals (SDGs) as an organizing framework (Leal Filho et al. 2019; Chang and Lien 2020; SDSN 2020; Chankseliani and McCowan 2021). The UN's adoption of the 2030 Agenda including the 17 SDGs signalled the need for global cooperation and "deep, structural changes across all sectors in society" (Sachs et al. 2019) to achieve their desired outcomes. The comprehensive nature of the SDGs mandates a pedagogical approach which encompasses the broad range of ecological, social, economic, and institutional dimensions of sustainability, and addresses the dynamic interconnections among the different goals (Willats et al. 2018; Brugmann et al. 2019; Leal Filho et al. 2019; Sachs et al. 2019). There is support for teaching the foundational knowledge of sustainability and SDGs in introductory level courses for sustainability programs and building into more SDG-specific areas of focus as students progress to higher level courses (Marcus et al. 2015; Chang and Lien 2020). Yet despite the benefits of framing course content around SDGs, studies have found professors have not widely adopted SDG teaching due to a lack of knowledge, resources, and time (Willats et al. 2018; Zamora-Polo and Sánchez-Martín 2019). Furthermore, relatively few HEIs have aligned their strategies with the SDGs despite the obvious connection between the responsibilities of universities and the objectives of the SDGs (Leal Filho et al. 2019; Chaleta et al. 2021; Sanchez-Carrillo et al. 2021).

Some recent literature calls for the integration and hybridization of an SDG-based approach and a core competencies-based approach (Zamora-Polo and Sánchez-Martín

2019; Brundiers et al. 2020; SDSN 2020). This hybrid approach allows for competencies to prepare students with the tools, methods, and skills needed to find actionable solutions for the real-world sustainability problems structured by the SDGs (Wiek et al. 2011; Díaz-Iso et al. 2019; Leal Filho et al. 2019; SDSN 2020), while the SDGs provide groundwork for the knowledge component of a core competencies framework. Combining these two approaches may provide a useful method to understand underlying sustainability issues and to promote interdisciplinarity and transdisciplinarity through the interconnections among the SDGs (Schrand et al. 2013; UNESCO 2017; Kishita et al. 2018; Brugmann et al. 2019; Leal Filho et al. 2019; Brundiers et al. 2020; Chang and Lien 2020; SDSN 2020; Chaleta et al. 2021).

Interdisciplinarity vs. transdisciplinarity

Universities shifting to sustainability learning have emphasized the importance of interdisciplinary and transdisciplinary collaboration in their program design (Sipos et al. 2008; Holmberg 2014; Wright et al. 2015; UNESCO 2017; Kishita et al. 2018; Leal Filho et al. 2018). The interdisciplinary approach refers to a pedagogical method that incorporates multiple disciplines of academia to provide students with a greater balance of learning and understanding of social problems. The transdisciplinary approach moves beyond the university, connecting students with community stakeholders to gain a real-world perspective on sustainability issues. Interdisciplinary learning is already relatively ingrained in many university sustainability programs (Sherren 2006; Schrand et al. 2013; Shriberg et al. 2013). An interdisciplinary approach to addressing the SDGs allows for multiple university departments to work together on issues related to sustainability (Brugmann et al. 2019; SDSN 2020). Inclusion of transdisciplinary experiences will allow students to build the competencies required for solving real-world problems that cannot be learned in a classroom setting (Wiek et al. 2014, 2014). Indeed, the complexity of solving today's societal issues demands external stakeholder collaboration and input in order to successfully address these issues in an effective, holistic way (Brundiers and Wiek 2013; Leal Filho et al. 2018; Sisto et al. 2020).

There is value then in incorporating both interdisciplinary and transdisciplinary approaches into sustainability programs. In this way, learning and collaboration in both formal and informal spaces can support the integration of the SDGs into sustainability programming (UNESCO 2017; Chang and Lien 2020). The very nature of the SDGs facilitates the involvement of diverse stakeholders in promoting sustainability within their university and throughout society (Willats et al. 2018). Further, the overarching themes of interdisciplinarity and transdisciplinarity could be emphasized in a core competency model as well, through incorporating a competency on interdisciplinary and transdisciplinary engagement and partnerships (Evans 2019; Roy et al. 2020). Facilitating input from a diverse group of faculty members and external stakeholders would not only boost sustainability learning among students, it could address the challenges that some faculty face when teaching within the sustainability space where their knowledge may not be sufficient.

Mandatory vs voluntary

With sustainable development emerging as a pressing topic for universities, many have recognized the roles of HEIs in educating future generations of students in sustainability and providing them with the necessary tools to become agents of change in their communities (Mintz and Tal 2014; Jarchow et al. 2017; Díaz-Iso et al. 2019; Leal Filho et al. 2019). This call to action has seen many universities adopting sustainability into their teachings on all scales, from integrating SDGs and core competencies into existing courses to complete university-wide curricula overhauls, stressing the importance of sustainability being embedded across all disciplines and of preparing every student with the tools and knowledge needed to tackle complex, real-world issues (Cayuela et al. 2013; Wiek et al. 2014; Marcus et al. 2015; Wright et al. 2015; Jarchow et al. 2017; Brugmann et al. 2019; Miñano Rubio et al. 2019; Chang and Lien 2020).

Universities have been offering different forms of sustainability programming and courses as a means of integrating sustainability into their curriculum. Often these programs share a common structure: introductory, mandatory courses that lay the groundwork of sustainability knowledge and competencies that can be built upon in future courses followed by elective courses for students to choose how and where they want to fill out their credits, often culminating in a capstone project course that applies the experiences and opportunities students have developed throughout the program to a real-world problem (Cayuela et al. 2013; Schrand et al. 2013; Mintz and Tal 2014; Wiek et al. 2014; Jarchow et al. 2017; Kishita et al. 2018). When opening up sustainability to the general student population, introductory courses are important ways of laying the foundations of sustainability knowledge (Brundiers et al. 2010; Cayuela et al. 2013; Marcus et al. 2015; Miñano Rubio et al. 2019; SDSN 2020).

Despite the theoretical value of new programs, in practice, many universities lack the resources and students lack the time and space in their course scheduling for new sustainability courses, therefore embedding sustainability into pre-existing courses is another popular, wide-reaching approach to teach sustainability (Mintz & Tal., 2014; Marcus et al. 2015; Miñano Rubio et al. 2019).

While these approaches work well for students choosing to focus on sustainability, offering sustainability programming to the large numbers of students not concentrating on sustainability issues raises important issues of accessibility and choice. Adding new mandatory courses for the whole student body would be logistically challenging and highly resource intensive. In such cases, offering voluntary, sustainability-focused courses and options as a means to satisfy program or graduation requirements has been found to be popular with students. It also avoids the problem of forcing sustainability into courses or programming where it does not obviously fit (Mintz and Tal 2014; Jarchow et al. 2017).

SDG-based inventories

As more universities focus on sustainability, efforts are being made to quantify their initiatives and document active sustainability efforts. Inventories have become popular and effective methods to fulfill this task, with the majority of them based upon the UN's SDGs as a metric. In addition to bringing sustainability practices around campus to light, inventories can support program development and foster dialogue and interdisciplinarity

amongst faculty and students (Cayuela et al. 2013; Brugmann et al. 2019). Inventories of sustainability courses can also act as an awareness and selection tool to support students interested in enrolling in sustainability courses. The SDG approach helps highlight areas of focus and connections between all levels of programming from individual courses to entire divisions, while exposing gaps of SDG coverage (Brugmann et al. 2019; Chang and Lien 2020). As a result, the breadth and availability of sustainability courses can be identified and informed collaborations can be made between disciplines to form new programs and implement sustainability into pre-existing programs (Chang & Lien., 2020).

Universities have pursued sustainability course inventories in different ways (Zamora-Polo and Sánchez-Martín 2019). For example, the University of Toronto and University of British Columbia have both established sustainability course inventories based on SDG keywords that are found in the course syllabi, with U of T expanding into community-engaged learning and co-curricular and extracurricular student groups inventories (Cayuela et al. 2013; Brugmann et al. 2019). These inventories have been successful in bringing previously overlooked sustainability opportunities and establishing interdisciplinary connections. The National University of Kaohsiung structured a slightly different course inventory, where a built-in module was provided to instructors to fill in and evaluate relevant SDGs and competencies covered in their courses (Chang and Lien 2020). They found that the number of SDGs per course reflected the diversity of sustainability, yet a high number of SDGs did not necessarily reflect the level of preparedness for a course or program to address that area of sustainability (Chang and Lien 2020).

The addition of inventories as a metric of sustainability initiatives acts as a useful tool that helps dictate course selection and identify areas of interdisciplinarity for sustainability programming and integration. It can be combined with an SDG approach to classify courses based on the aspects of sustainability the course covers, yet more work needs to be done in auditing the course to ensure it has sufficient coverage of the material.

Challenges with changing pedagogical approaches

Several universities have highlighted challenges they faced or may face in the process of shifting away from traditional pedagogy towards a system that integrates sustainable development. A study of the University of North Dakota's sustainability major course syllabi determined that core courses had better implementation of all student learning outcomes (SLOs) compared to elective courses. However, faculty in general lacked training which led to poorer understanding of SLOs, thus diminishing the instructors' abilities to address them in their respective courses and lowering the implementation rate (Jarchow et al. 2017). At Arizona State University, it was noted that while students engaged in solution-oriented sustainability learning had largely positive experiences, there were shortcomings such as time restraints resulting in more surface-level experiences of sustainability problem-solving as well as faculty and stakeholder unfamiliarity with this pedagogical approach (Wiek and Kay 2015). Pompeii et al. found similar barriers, citing time constraints and general disinterest in sustainability as reasons for a lack of student involvement. They suggest that these barriers may be overcome through linking sustainability to career opportunities and integrating sustainability into existing curricula (Pompeii, 2019).

In the six universities that Brundiers and Wiek studied, programs failed to structure themselves in a way that required the prerequisites necessary for the culminating problem- and project-based learning (PPBL) courses (2013). Universities have struggled creating courses that sufficiency include the role of stakeholders. Therefore, communication of expectations, results, learning objectives, and standards of quality between students and stakeholders is needed for the benefit of both student and stakeholder (Brundiers and Wiek 2013). Sherren's study of Canadian universities found program designs that differ from the standard model which universities follow can run into administrative issues when determining "subject numbers, credit value, workload formulae and timetabling" (2006). Other researchers have predicted a reluctance to move away from the tried and true way of traditional pedagogical methods. If change occurs without an end goal, there can be a period of chaos throughout the reorganization phase (Miller et al. 2011).

While the literature discussed in this section of the paper is largely focused on sustainability pedagogy aimed at students targeting sustainability issues in their academic program, it provides important lessons that extends to any attempts in developing more general sustainability programming. Each emergent theme from the literature acts as a focal point of development, where the key takeaways can be implemented to guide course curation, learning outcomes, program structure, and partnerships both within and outside of the university. We will return to these lessons after describing the U of T Sustainability Pathways program.

U of T Sustainability Pathways program

At U of T, the President's Advisory Committee on the Environment, Climate Change and Sustainability ((CECCS) has been working since 2017) to establish university-wide sustainability learning trajectories, called Sustainability Pathways with the following attributes:

- Accessible to all undergraduate students regardless of degree program;
- Interdisciplinary and transdisciplinary;
- Can be completed by students within their existing degree programs;
- Involve research, co-curricular projects and/or community-engaged learning courses; and
- Provide a coherent sustainability education (CECCS Annual Reports 2017, p. 2018, 2019, 2020 and 2021).

An underlying premise of this approach is that while sustainability professionals will continue to be needed for the foreseeable future, it is extremely important that students who are not specializing in sustainability issues also have the opportunity to add sustainability to their education. From this point of view, the concept of "green jobs" is not useful. Instead, it can be argued that all jobs are both in the world and involve other people. Thus all jobs and occupations have important sustainability dimensions, both environmental and social. All graduates of the university should therefore be able to use sustainability knowledge and skills in whatever job they may find themselves (Díaz-Iso et al. 2019; Leal Filho et al. 2019). Indeed, arguably, a major function of our education system should be to train students as agents of change, from a sustainability point of view, so that they can

actively support the sustainability transition in their place of employment. The limited experience to date at U of T suggests that this message is a welcome one to students suffering from eco-anxiety, who are looking for positive strategies for change that they can adopt.

U of T Sustainability Pathways are specially curated courses across various disciplines with a common theme of sustainability. Pathways add integrated sustainability content to a student's degree program, and can be helpful in understanding interconnectedness, relationships, and complexities among ideas that would otherwise not be readily realized in that degree. Sustainability Curricular Pathways provide each undergraduate student with an opportunity to add sustainability learning to their degree no matter what program(s) they are enrolled in, and to develop cross-cutting interdisciplinary skills which literature has been identified as being crucial (Wright et al. 2015; Leal Filho et al. 2018).

To this end, U of T has developed a three-tiered Sustainability Pathways program:

- Sustainability Citizen – Student completes a certain number of approved sustainability-oriented co-curricular activities
- Sustainability Scholar – Student completes the Sustainability Curricular Pathways in the form of a Certificate or Minor in sustainability
- Sustainability Leader – Student completes Citizen and Scholar requirements, and adds an experiential learning capstone activity

The program aims to inspire and encourage students to voluntarily incorporate sustainability learning in their curricular and extracurricular activities with formal recognitions on their academic transcripts (Sustainability Scholar), their Co-Curricular Record (Sustainability Citizen), or both (Sustainability Leader).

The program was modelled after original plans for the Global University Program at U of T, which proposed the three-tiered approach described here.

Since U of T's Sustainability Pathways program is intended to include students who have not chosen sustainability as their major or program focus, mandatory courses have been avoided because of the difficulties of creating university-wide mandatory courses, concerns about the pedagogical value of such courses, and the danger they pose of engendering a distaste for sustainability issues in students who take such courses only because they have to do so. Instead, the goal is to design voluntary programs that are appealing to those without current access to this kind of learning – in this case 96% of U of T's undergraduate student population. The voluntary nature of participation has the advantage that there is immediate feedback on the appeal of such programs, which can be used to adjust them over time.

Taking a step back and looking at both the various sustainability programs and the Sustainability Pathways program at U of T, the larger picture is that of a hybrid approach. That is, sustainability programs, by definition, offer required core courses. On the contrary, for all the other students – the ones we target with the Sustainability Pathways program, a voluntary approach seems more appropriate.

Another important consideration has to do with the conception of, and approach to, sustainability that underlies the Sustainability Pathways program. At U of T, we have adopted the concept of regenerative sustainability, which goes beyond damage

limitation and harm reduction approaches, and a narrow focus on the environment, to look first for forms of human activity that improve human and environmental wellbeing (Robinson and Cole 2015; CECCS 2017). An example would be a building that is net positive in energy, carbon and water, and also in terms of human health, productivity and subjective wellbeing. One might also refer to such approaches as "net positive". While net positive solutions are not always possible in all circumstances, they offer an approach to sustainable development that remains largely underexplored and potentially responsive to calls for hope in the face of growing eco-anxiety. This combined human/environmental agenda, and the focus on improvement, not just damage mitigation, are both embodied in the UN SDGs which, at the level of the goals themselves, provide a powerful heuristic framework, demonstrating the breadth and the interconnected nature of the multiple dimensions of sustainability.

Future work in developing the U of T Sustainability Pathways program will adopt the hybrid approach discussed above whereby the SDGs outline the substance of concern (the "what") (Zamora-Polo and Sánchez-Martín 2019; Chang and Lien 2020; Chankseliani and McCowan 2021) while core competencies are about how students can usefully address sustainability issues (the "how") (Brundiers and Wiek 2013; Schrand et al. 2013; Wiek and Kay 2015).

A final consideration has to do with interdisciplinarity and transdisciplinarity. While the need for interdisciplinary approaches to sustainability issues is widely accepted (though sometimes reflected more in the rhetoric than the practice of universities), there is less recognition of the need for transdisciplinary approaches that involve non-academic partners actively in the research process itself. Attention to the principles of interdisciplinary and especially transdisciplinary learning is also relatively uncommon in undergraduate programming.

It is hard to imagine a teaching practice more in need of transdisciplinary approaches than the teaching of sustainability where the value of an approach based on knowledge co-production and generating actionable knowledge is pronounced. This can be done by encouraging interdisciplinary engagement and experiential learning through internships, community engaged learning, and co-op programs (Evans 2019). In turn this means that teaching practices must be attuned to both interdisciplinary and non-academic engagement, in ways that don't easily fit the disciplinary structure of academic departments, or the skill sets of many faculty. It is no accident that most sustainability programs at universities, for example, occur in interdisciplinary and transdisciplinary programs that tend to exist at the interstices of disciplinary structures and departments. They are often taught in what Julie Thompson Klein (1990) has called the "interdisciplines", like environmental science or studies, planning, public health, women and gender relations, etc. Fortunately the number of these hybrid departments and programs is growing, as is the attention being paid to various kinds of "living lab" approaches which involve strong links to non-academic partners. However, most students at the university will not be enrolled in such programs, but will get their degree within a disciplinary program, where transdisciplinary approaches may be rare.

Taking these considerations into account the question focused on at U of T in developing the Sustainability Pathways program is how to design a voluntary program that will provide integrated curricular and co-curricular pathways to explore sustainability issues for all undergrad students, regardless of what program they are enrolled within. This

necessitates a highly distributed approach in which separate Pathways are developed within each faculty at the university, since at U of T, as at many other universities, cross-faculty programs are rare and very difficult to create and sustain (Brugmann et al. 2019).

Development of the Sustainability Scholar program has been underway across five divisions: Faculty of Applied Science & Engineering (FASE); Faculty of Architecture, Landscape and Design; Faculty of Arts & Science; U of T Scarborough (UTSC); and U of T Mississauga (UTM). The first four have now approved either a certificate or minor in sustainability. The total number of enrolled students in the inaugural term (Fall 2021) of Sustainability Scholar Programs at these divisions is 361. Work is progressing at UTM, aiming for a 2022 launch. Other faculties will follow.

All divisional programs are approved as new undergraduate, for-credit certificates or minors that will be offered in conjunction with existing undergraduate degree programs. Creation of these programs follow the protocols for minor modifications managed by the divisions, following an established path of approval (i.e. governance) at the divisional level.

Although each division designs and approves their own certificate or minor for the Sustainability Scholar designation, the transcript indicates "U of T Sustainability Scholar" in parentheses after the name of the certificate or minor. This is important for branding, communications and coding purposes for the pan-university Sustainability Scholar Program. It indicates that the certificate or a minor program was not an initiative of one faculty but an area of institutional importance.

With regards to the Sustainability Citizen tier, the CECCS has been working with U of T's Student Life team, Sustainability Offices on the three campuses, and student research assistants to develop this opportunity for students to actively participate in sustainability-related activities while building important skills and knowledge. A required introductory training module for all students interested in the Citizen program is under development. Recognizing scarce resources, a Planning Group is exploring the most feasible way to validate sustainability-oriented activities and student group leadership positions. They are also designing a framework for co-curricular record opportunities eligible for Citizen recognition, including a student-generated accreditation model, and defining the expected learning outcomes. The program is being designed with significant input from the student research assistant focus group.

Once the first two tiers are in place, the third tier of Sustainability Leader program will be developed. The Leader tier will be designed so that the integration and reflection process of a capstone, incorporating experiential learning, would bring otherwise separate elective elements of the Citizen and Scholar tiers together and guide students onto a leadership path in sustainability.

An important component of the Sustainability Pathways program is the plan, based on student suggestions, to develop leadership workshops and training sessions to give students the skills and tools to become agents of change for sustainability in whatever organization they work for after graduation. Creating such change may be a highly impactful activity for them, and an important component of their sustainability education.

A prerequisite for developing the Sustainability Pathways Program has been the creation of a number of inventories of the sustainability teaching, research and other activities already going on at the university. To that end the following seven inventories have been developed, all based on using SDG keywords, and all updated regularly:

- An inventory of all undergraduate courses that speak to one or more of the SDGs
- An inventory of community-engaged learning (CEL) courses that focus on sustainability issues
- An inventory of all student groups that focus on sustainability issues
- An inventory of all community engaged learning (CEL) and campus as a living lab (CLL) projects focused on sustainability
- An inventory of all Masters theses and PhD dissertations that address sustainability issues
- An inventory of all graduate programs with sustainability orientation
- An inventory of all research units that conduct sustainability research

Student engagement was key in the compilation of these inventories. And the annual update of all inventories has been led by students. The documentation of the initial process was presented by those students at the International Sustainable Campuses Network (ISCN) conference in 2018 and subsequently received an award for the best student research paper presented by the Association for the Advancement of Sustainability in Higher Education (AASHE) in 2019.

These inventories provide a snapshot of sustainability activities at the university and the faculty and students involved in those activities. They are an indispensable input to designing sustainability minors and certificates in each faculty. They allow the identification of faculty that are teaching sustainability-related content, with a view to developing communities of practice of sustainability instructors, and sustainability CEL instructors. They also allow the course and student club inventories to be made available to students who might be interested. They will help identify alumni who have done graduate work in sustainability, who might be interested in serving as mentors for our current students.

Evaluation of the Pathways Program

We turn now to an evaluation of U of T's Sustainability Pathways program, based on the four key themes discussed above.

It was suggested above that incorporating core competencies into an SDG-centred conceptual framework provides students with the knowledge and skills to create sustainable change after graduation. As currently structured, the Sustainability Pathways program does not focus on core competencies, but is structured around the SDGs. This orientation provides a useful and valuable way to structure courses and measure engagement with the SDGs that stand for the breadth of sustainability issues confronting society, a hybrid approach that integrates core competencies into the program can be expected to benefit students and will be explored once the current framework is fully established.

The integration of interdisciplinarity and transdisciplinarity approaches into programming would further benefit the teaching and learning experience. The Pathways program places emphasis on interdisciplinary approaches through its inclusion of diverse faculty in student teaching and learning. It also promotes transdisciplinarity as students participate in various forms of community-engaged learning and real-world sustainability problem-solving. That being said, the challenges of faculty engagement and knowledge should not

be under-estimated, and the need for a whole institution approach, in which the university itself addresses sustainability pedagogy across the institution, is apparent.

Another important theme from the literature review addressed **whether sustainability courses or programs are mandatory or voluntary**. While many HEIs have adopted introductory, mandatory courses that lay the groundwork of sustainability knowledge in their sustainability programs, the Pathways program has been developed to be entirely voluntary based on scepticism about the pedagogical value of mandatory courses and the logistical challenges of creating and administering them university-wide. However, a higher level view of sustainability learning at U of T demonstrates a hybrid approach of the existing sustainability programs offering required core courses while the Pathways program is open for voluntary participation to all other students in pursuit of reaching the rest. A voluntary approach seems more appropriate and complementary considering the target student population.

With the literature demanding increased sustainability pedagogy across HEIs, the Pathways program fulfils that demand by providing the opportunity to all students. Within the three tiers, the Scholar tier closely resembles the archetype of common sustainability programming. Five undergraduate faculties have taken up the Scholar program, offering minors or certificates in sustainability for their students developed from previous courses and/or programs.

The structure of the Pathways program differs from traditional, course-focused sustainability programming by including the Citizen tier which requires only co-curricular activities and the Leader tier which adds experiential learning on top of Citizen and Scholar completion. The Leader tier transforms their experiences and knowledge into a capstone project which has seen success in integrating the classroom and the real-world through transdisciplinary efforts. The Citizen tier offers an opportunity for students to gain recognition for past activities and get involved in more sustainability events without affecting their academic paths.

The SDG-based inventories, more specifically the Sustainability Undergraduate Course Inventory, which U of T has been updating annually since 2017, has permitted a comprehensive and coherent approach to sustainability teaching and learning (Brugmann et al. 2019). They have been crucial in demonstrating how much sustainability activity is currently ongoing, validating and connecting existing efforts on sustainability-related issues, providing a basis for future research (e.g. which SDGs are best covered in current courses), and developing communities of practice for sustainability instructors. While we do not have analytics yet, we do know that inventories are used extensively by members of the U of T community for external reporting purposes including rankings. In the summer of 2022, the CECCS' cross-disciplinary team of sustainability faculty members, staff and students ran a critical, fine-grained review of the SDG keywords used in updating the inventories. We asked if the keywords accurately reflected how we defined courses to have sustainability content in light of the goal of maintaining an up-to-date sustainability course inventory publicly accessible. The list of 73 keywords first established by the (CECCS in 2017) and published by (Brugmann et al. in 2019) was revised to add more keywords based on the UN Global Indicator Framework for SDG; add more related to Indigenous worldviews and equity, diversity, and inclusion that are not immediately obvious in the SDG framework; and remove those that had been determined to be too broad and therefore yielding too many "false positives". As a result, the list grew to include

388 keywords. The keyword review and more broadly the re-evaluation of the purpose of the inventories was a learning process for all involved that will be repeated each year.

U of T has been contacted by a number of HEIs interested in starting a sustainability course inventory of their own. The CECCS co-led workshops on methods and strategies for developing sustainability-oriented course and activity inventories in response to significant interest in learning more about how to do this amongst a group of signatory universities in the U7+ Alliance, a unique international partnership that brings together 50+ leading universities in the world to tackle the most pressing global challenges such as climate change and sustainability. As further evidence of impact, U of T's SDG keywords were cited in the Vrije Universiteit Amsterdam's' presentation on their inventory of SDG courses in the ISCN conference in 2022.

Two years have passed since the launch of the first Curricular Pathways program at the Faculty of Architecture, Landscape and Design, and one year at the Faculties of Applied Science & Engineering and Arts & Science, and at the University of Toronto Scarborough.

The 2021–22 enrolment total across the four existing programs is 390 students. It remains to be seen if this number will grow to reach a significant fraction of undergraduate students at U of T. The enrolment numbers and growth trends will continue to be monitored as a communications strategy specifically for the Pathways program will be developed. The strategy will include the Faculty of Applied Science & Engineering's track record of marketing its Pathways program and ways to apply it at an institutional level, and a promotion campaign to be staged at the next orientation event for incoming students. The Pathways program and the inventories will also be promoted in the next iteration of the university-wide event series hosted by the CECCS to celebrate successes and collaboratively deepen campus engagement around sustainability.

In addition, the CECCS will be the client of a campus-as-living-lab course project in the fall of 2022 to assess the Curricular Pathways program, including its faculty programs, to improve enrolment. The group of students taking on this project will be asked to conduct a survey of students participating in the program, further review the analytics on the use of inventories, compare the marketing experience across faculties and implementation years, and then make recommendations to better understand factors influencing student awareness and enrolment.

Efforts to improve and enhance the Curricular Pathways programs have been ongoing in the divisions that have started implementing. Some have developed a newly dedicated course in which the pedagogy is more aligned with the division's intended learning outcome with an emphasis on interdisciplinarity and/or transdisciplinarity. For some, the Curricular Pathways Program was leveraged as a vehicle for cultural change within the division where sustainability pedagogy did not exist, was only vaguely defined, or was not shared. In addition, now that there are multiple divisions implementing the Pathways Program, it is being leveraged for inter-divisional collaboration around developing new offerings including interdisciplinary courses, community-engaged learning courses, and/or campus-as-a-living-lab courses that have been on a steady rise.

Conclusion

From the literature review, the four identified themes provided insight on sustainability program design. A hybridization of the two main frameworks combining SDG and core competency based approaches best prepares students with the tools, skills, and required knowledge foundation to tackle real-world sustainability issues and synergizes with both interdisciplinarity and transdisciplinarity – two necessary components that promotes collaboration amongst disciplines and with external parties that extends beyond the classroom. SDG-based inventories help identify areas of interdisciplinarity amongst subjects, making them a valuable resource in program design. Mandatory, introductory courses hold their value in sustainability programs, but when introducing sustainability to the entire student body, voluntary courses offer a wider range of accessibility and are less logistically challenging.

The Sustainability Pathways program outlined here is intended to offer a practical path towards sustainability teaching and learning at universities that is aimed at the large number of students not specializing in sustainability issues. When evaluated in terms of the four themes found in the literature on sustainability pedagogy, it is found to address several of them directly while suggesting room for improvement in others. With regard to adopting an SDG framework vs a core competencies approach, the Pathways program is strongly rooted in an SDG framework. Given that orientation, the program makes extensive use of SDG-based inventories. However, the program could benefit from adding components focussed on core competencies.

With its emphasis on experiential learning courses, the Program focuses on building both interdisciplinary and transdisciplinary skills. However, more work needs to be done to foster interdisciplinarity, across Faculties and Divisions. And, given the relative novelty and unfamiliarity of transdisciplinary knowledge co-production processes, more work is needed to support skill development in this area. On the tension between mandatory and voluntary course approaches, the Sustainability Pathways program takes the latter, but in the big picture of sustainability education at U of T, the approach is hybrid. There are 56 sustainability-oriented programs at U of T and in each of them, there are of course mandatory courses. The Pathways program, aimed at the whole student body, does not have mandatory courses.

Perhaps most importantly, the Sustainability Pathways program is intended to reach a much larger fraction of the student population than other approaches aimed at increasing the number and popularity of programs for students who want to specialize in sustainability issues. However, it remains to be seen how many students not explicitly focused on sustainability in their undergraduate degree choose to add sustainability content by pursuing this program. This will be the true test of its success.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Declaration of Interest Statement

The authors declare no potential conflict of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author, [AA], upon reasonable request.

References

Bianchi G; Joint Research Centre (JRC). 2020. Sustainability competences: a systematic literature review. Publications Office of the European Union. https://publications.jrc.ec.europa.eu/repository/handle/JRC123624

Brugmann R, Côté N, Postma N, Shaw EA, Pal D, Robinson JB. 2019. Expanding student engagement in sustainability: using SDG- and CEL-focused inventories to transform curriculum at the University of Toronto. Sustainability. 11(2):530. doi:10.3390/su11020530

Brundiers K, Barth M, Cebrián G, Cohen M, Diaz L, Doucette-Remington S, Dripps W, Habron G, Harré N, Jarchow M, et al. 2020. Key competencies in sustainability in higher education - toward an agreed-upon reference framework. Sustain Sci. doi:10.1007/s11625-020-00838-2

Brundiers K, Wiek A. 2013. Do we teach what we preach? An international comparison of problem-and project-based learning courses in sustainability. Sustainability. 5(4):1725–1746. doi:10.3390/su5041725

Brundiers K, Wiek A, Redman C. 2010. Real-world learning opportunities in sustainability: from classroom into the real world. Int J Sustain High Educ. 11(4):308–324. doi:10.1108/14676371011077540

Cayuela A, Robinson JB, Campbell A, Coops N, Munro A. 2013. Integration of operational and academic efforts in sustainability at the University of British Columbia. In: Azeiteiro UM, Caeiro S, Filho WL, Jabbour C, editors. Sustainability assessment tools in higher education institutions. Cham: Springer. doi:10.1007/978-3-319-02375-5_13

CECCS. (2017). Annual Report 2017. President's Advisory Committee on the Environment, Climate Change, and Sustainability (CECCS). https://live-presidents-office.pantheonsite.io/wp-content/uploads/2021/12/2017-ECCS-annual_report-1.pdf

Chaleta E, Saraiva M, Leal F, Fialho I, Borralho A. 2021. Higher education and Sustainable Development Goals (SDG)—potential contribution of the undergraduate courses of the school of social sciences of the University of Évora. Sustainability. 13(4):1828. doi:10.3390/su13041828

Chang Y, Lien H. 2020. Mapping course sustainability by embedding the SDGS inventory into the university curriculum: a case study from National University of Kaohsiung in Taiwan. Sustainability. 12(10):4274. doi:10.3390/su12104274

Chankseliani M, McCowan T. 2021. Higher education and the sustainable development goals. High Educ. 81(1):1–8. doi:10.1007/s10734-020-00652-w1

Díaz-Iso A, Eizaguirre A, García-Olalla A. 2019. Extracurricular activities in higher education and the promotion of reflective learning for sustainability. Sustainability. 11(17):4521. doi:10.3390/su11174521

Evans TL. 2019. Competencies and pedagogies for sustainability education: a roadmap for sustainability studies program development in colleges and universities. Sustainability. 11(19):5526. doi:10.3390/su11195526

Holmberg J. 2014. Transformative learning and leadership for a sustainable future: challenge lab at chalmers university of technology. In: Corcoran PB, Hollingshead BP, editors. Intergenerational learning and transformative leadership for sustainable futures. Wageningen Academic Publishers. doi:10.3920/978-90-8686-802-5_4

Jarchow ME, Formisano P, Nordyke S, Sayre M. 2017. Measuring longitudinal student performance on student learning outcomes in sustainability education. Int J Sustain High Educ. doi:10.1108/IJSHE-11-2016-0200

Kishita Y, Uwasu M, Hara K, Kuroda M, Takeda H, Umeda Y, Shimoda Y. 2018. Toward designing sustainability education programs: a survey of master's programs through semi-structured interviews. Sustain Sci. 13(4):953–972. doi:10.1007/s11625-018-0546-5

Klein JT. 1990. Interdisciplinarity: history, theory, and practice. Wayne State University Press.
Leal Filho W, Raath S, Lazzarini B, Vargas VR, de Souza L, Anholon R, Quelhas OL, Haddad R, Klavins M, Orlovic VL. 2018. The role of transformation in learning and education for sustainability. J Clean Prod. 199:286–295. doi:10.1016/j.jclepro.2018.07.017
Leal Filho W, Shiel C, Paço A, Mifsud M, Veiga Ávila L, Londero Brandli L, Molthan-Hill P, Pace P, Azeiteiro UM, Ruiz Vargas V, et al. 2019. Sustainable development goals and sustainability teaching at universities: falling behind or getting ahead of the pack? J Clean Prod. 232:285–294. doi:10.1016/j.jclepro.2019.05.309
Marcus J, Coops NC, Ellis S, Robinson J. 2015. Embedding sustainability learning pathways across the university. Curr Opin Environ Sustain. 16:7–13. doi:10.1016/j.cosust.2015.07.012
Miller TR, Muñoz-Erickson TA, Redman CL. 2011. Transforming knowledge for sustainability: towards more adaptive and engaged academic institutions. Int J Sustain High Educ. 12(2):177–192. doi:10.1108/14676371111118228
Miñano Rubio R, Uribe D, Moreno-Romero A, Yáñez S. 2019. Embedding sustainability competences into engineering education. the case of informatics engineering and industrial engineering degree programs at Spanish universities. Sustainability. 11(20):5832. doi:10.3390/su11205832
Mintz K, Tal T. 2014. Sustainability in higher education courses: multiple learning outcomes. Stud Educ Evaluation. 41:113–123. doi:10.1016/j.stueduc.2013.11.003
Pompeii B, Chiu Y, Neill D, Braun D, Fiegel G, Oulton R, Ragsdale J, Singh K. 2019. Identifying and overcoming barriers to integrating sustainability across the curriculum at a teaching-oriented university. Sustainability. 11(9):2652. doi:10.3390/su11092652
Robinson J, Cole RJ. 2015. Theoretical Underpinnings of regenerative sustainability. Build Res Inf. 43 (2):133–143. doi:10.1080/09613218.2014.979082
Roy SG, de Souza SP, McGreavy B, Gottschalk Druschke C, Hart DD, Gardner K. 2020. Evaluating core competencies and learning outcomes for training the next generation of sustainability researchers. Sustain Sci. 15(2):619–631. doi:10.1007/s11625-019-00707-7
Sachs JD, Schmidt-Traub G, Mazzucato M, Messner D, Nakicenovic N, Rockström J. 2019. Six transformations to achieve the sustainable development goals. Nat Sustain. 2(9):805–814. doi:10.1038/s41893-019-0352-9
Sanchez-Carrillo JC, Cadarso MA, Tobarra MA. 2021. Embracing higher education leadership in sustainability: a systematic review. J Clean Prod. 298:126675. doi:10.1016/j.jclepro.2021.126675
Schrand T, Benton-Short L, Biggs L, Bryson M, Habron G. 2013. Teaching Sustainability 101: how do we structure an introductory course? Sustainability. 6(4):207–210. doi:10.1089/sus.2013.9853
SDSN. 2020. Accelerating education for the SDGs in universities: a guide for universities, colleges, and tertiary and higher education institutions. New York: Sustainable Development Solutions Network (SDSN).
Sherren K (2006). Silos, students and centralising forces: the institutional climate affecting innovations for sustainability in the tertiary sector. *AARE Conference*. Adelaide, Australia.
Shriberg M, Schwimmer S, MacDonald L. 2013. University of Michigan's sustainability scholars program: empowering leaders. Sustainability. 6(5). doi:10.1089/sus.2013.9842
Singer-Brodowski M, Wanner M, Schneidewind U. 2018. Real-world laboratories as an institutionalisation of the new social contract between science and society. Padmanabhan M, editor. Transdisciplinary Research and Sustainability. Routledge.
Sipos Y, Battisti B, Grimm K. 2008. Achieving transformative sustainability learning: engaging head, hands and heart. Int J Sustain High Educ. 9(1):68–86. doi:10.1108/14676370810842193
Sisto R, Sica E, Cappelletti GM. 2020. Drafting the Strategy for Sustainability in Universities: a Backcasting Approach. Sustainability. 12(10):4288. doi:10.3390/su12104288
UNESCO. 2017. Education for sustainable development goals: learning objectives. Paris, France: United Nations Educational, Scientific and Cultural Organization (UNESCO).
Wiek A, Kay B. 2015. Learning while transforming: solution-oriented learning for urban sustainability in Phoenix, Arizona. Curr Opin Environ Sustain. 16:29–36. doi:10.1016/j.cosust.2015.07.001
Wiek A, Withycombe L, Redman CL. 2011. Key competencies in sustainability: a reference framework for academic program development. Sustain Sci. 6(2):203–218. doi:10.1007/s11625-011-0132-6

Wiek A, Xiong A, Brundiers K, van der Leeuw S. 2014. Integrating problem- and project-based learning into sustainability programs. Int J Sustain High Educ. 15(4):431–449. doi:10.1108/IJSHE-02-2013-0013

Willats J, Erlandsson L, Molthan-Hill P, Dharmasasmita A, Simmons E. 2018. A university wide approach to embedding the sustainable development goals in the curriculum—a case study from the Nottingham Trent University's Green Academy. In: Leal Filho W, editor. *Implementing Sustainability in the Curriculum of Universities. World Sustainability Series*. Cham: Springer. doi:10.1007/978-3-319-70281-0_5

Wright MF, Cain KD, Monsour FA. 2015. Beyond sustainability: a context for transformative curriculum development. J Teach Educ. 8(2).

Zamora-Polo F, Sánchez-Martín J. 2019. Teaching for a better world. sustainability and sustainable development goals in the construction of a change-maker university. Sustainability. 11(15):4224. doi:10.3390/su11154224