Building Capacity and Awareness for the UN Sustainable Development Goals Through Project-Based and Community-Engaged Pedagogies

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Abstract

Purpose - The key sustainability competencies are fundamental to sustainability transformations. The purpose of this study is to investigate the effectiveness of project-based and community-engaged pedagogies in supporting student development of all key sustainability competencies. Additionally, the study examines whether the UN SDGs provide an appropriate framework to support engagement with the breadth of sustainability topics and increase awareness and support of the goals within the community.

Design - This case study triangulates scaled self-assessment, performance observation, and regular course work in an undergraduate interdisciplinary sustainability course to gain insights into how all key sustainability competencies can be developed through recommended pedagogies.

Findings - Project-based and community-engaged pedagogies are supportive of key sustainability competencies development. The act of engaging with an interdisciplinary group towards achieving a common goal created effective learning opportunities for students. However, the project-based and community-engaged pedagogies cannot be completely separated from the context of the course. The use of the SDGs to guide community partner participation and project development was effective in increasing awareness of the goals among students and community partners.

Implications - These findings support the use of project-based and community-engaged pedagogies to facilitate student development of key sustainability competencies.

Originality - This study demonstrates that using the SDGs to guide community partner participation and project development is effective both in facilitating a wide range of projects from the identified areas of sustainability: environment, economic, social, and cultural, and in increasing awareness of the goals among students and community organizations.

Keywords: sustainability competencies; sustainable development goals; community-engaged learning; project-based learning; pedagogies

Purpose

The world is facing multiple sustainability crises. The United Nations (UN) Sustainable Development Goals (SDGs) (United Nations Educational, Scientific and Cultural Organization (UNESCO), 2017) present a vision of a desired future. However, without leaders who can successfully navigate the complex realities of current and future sustainability scenarios the world will be unsuccessful in achieving the SDGs. The literature offers both key sustainability competencies, identified as essential to leading transformative change (Redman and Wiek, 2021) and recommendations on pedagogies (Lozano *et al.*, 2017; Evans, 2019). By integrating the SDGs within a community-based teaching and learning context educators have the potential to create real-life, tangible learning opportunities to support the development of sustainability competencies and increased participation and support for the SDGs now and in the future.

Education experiences contribute directly to Sustainable Development Goal 4, Quality Education, Education for sustainable development and global citizenship. This study leverages Target 4.7 to "ensure that all learners acquire the knowledge and skills needed to promote sustainable development" (United Nations, 2015, Goal 4) by examining both the pedagogy and the assessment of sustainability competencies. The goal is to educate the leaders, so they are prepared to act in this UN declared Decade of Action 2020-2030 and throughout their lives. This study contributes to discussions of how to teach and how to assess sustainability education. It is essential that citizens can identify problems, solutions and actionable approaches that contribute to social, economic, environmental, and cultural sustainability. If these underlying competencies are lacking, citizens will not be able to identify and take the required actions to achieve the goals, that is why sustainability education matters.

Key Sustainability Competencies

Although sustainability is a recognized academic field and profession, and there are many sustainability programs established at universities around the world, consensus on program level learning objectives and the key sustainability competencies required to achieve those objectives has been a challenge (Sterling *et al.*, 2017; Trencher *et al.*, 2018; Brundiers *et al.,* 2021). Brundiers et *al.* (2021) have attempted to address this lack of clarity and consensus by collecting feedback from 14 international sustainability experts on the Wiek *et al.* (2011) and Wiek *et al.* (2016) developed competencies. Sustainability experts generally agreed with the existing competencies, but suggested refinements including additional competencies, specifying learning objectives, and recommending greater interconnectedness (Brundiers *et al., 2021,* p. 18). Redman and Wiek (2021) also found that the existing competencies framework was well accepted in the literature but required some renaming to support understanding and the addition of new competencies suggested by Brundiers *et al.* (2021).

The competencies used in this study, were those put forward by Wiek *et al.* (2011), which are the most cited key sustainability competencies (Trencher *et al.*, 2018, p. 831; Brundiers *et al.*, 2021, p. 18). At the time of the development of this study, neither Brundiers *et al.* (2021) nor Redman

and Wiek (2021) had published their studies recommending additional competencies. The competencies used within the context of the current study are in Table 1.

Table 1: Definition for Each Key Competencies for Sustainability

Competency	Description
Systems-thinking	The ability to analyze complex systems, taking different domains – such as society, environment, economy, and culture – and scales – local to global – into account. Feedback loops, leverage points, and other systemic features are considered.
Anticipatory (renamed Futures-Thinking in Redman and Wiek, 2021)	The ability to think about the future both in terms of forecasting from current scenarios and in anticipating the future outcomes of sustainability action plans or strategies.
Normative (renamed Values-Thinking in Redman and Wiek, 2021)	The ability to map, apply, and negotiate sustainability values, principles, goals, and targets particularly in relation to current and/or future states of systems.
Strategic	The ability to apply knowledge of complex systems to construct and test action plans for sustainability
Interpersonal	The ability to collaborate and participate in meaningful ways to contribute to teams and work with diverse stakeholders

With general agreement regarding key sustainability competencies, it is pertinent to identify the most appropriate pedagogical strategies for developing these competencies (O'Brien and Sarkis, 2014; Wiek and Kay, 2015; Trencher *et al.*, 2016; Ortega-Sanchez *et al.*, 2018). Project/problem-based learning, often with a community partner is frequently used (Evans, 2019, p. 5542) and recommended as an effective pedagogy for sustainability education (Cörvers *et al.*, 2016, p. 357). Trencher *et al.* (2018) found that practice-oriented sustainability masters programs which emphasize real-life problem solving and learning opportunities, often through projects with external partners "demonstrat[ed] higher success in building interpersonal, strategic and normative competencies" (Abstract).

This perspective is supported by de Haan (2006, p. 22) who argues that competence-oriented education should focus on output, or what is learnt, versus a conventional syllabus approach of focusing on input, or what is taught, to incorporate problem solving and real-world project-based approaches required by sustainability challenges. This corresponds to the idea of competence as the ability "to perform a task or an activity consistently over time and in different situations" (Green and Levy, no date, What do we mean by competence?, para. 3). Project-based, problem-based, and community-engaged learning address outputs because they are not focused on specific

subjects that students need to study, but on asking "what problem-solving strategies, concepts and abilities for social action they should have" (de Haan, 2006, p. 22).

Finally, Lozano *et al.* (2017) found that problem/project-based learning and community service learning (related to community-engaged learning) were covered the greatest number of different competencies. This aligns with Cörvers *et al.* (2016, p. 356) who also suggest that problem/project-based learning offer a broad opportunity to develop sustainability competencies, particularly when engaged with "real-world sustainability issues".

Redman and Wiek (2021) argue that the competencies are fundamental to achieving the societal transformations that are required by the SDGs. Further, the values that underlie the SDGs are fundamental to the successful application of the competence within a sustainability context (Brundiers *et al.*, 2021). The SDGs are intended to address current real-world challenges. Therefore, using the SDGs as a framework for developing key sustainability competencies is appropriate. Identifying and applying effective pedagogical strategies for developing sustainability competencies is thus vital to achieving SDG 4.

The UN SDGs require sustainability competencies as per UNESCO's (2017) "Education for Sustainable Development Goals: Learning Objectives". There is much written about how the SDGs can be incorporated into developing sustainability competencies, with Brundiers *et al.* (2021 p. 20) being a recent example. There is no shortage of articles and case studies examining the use of project/problem-based thinking and learning to address the challenges that must be overcome to achieve the SDGs, some examples include, Lehmann *et al.* (2008), Yasin and Rhaman (2011), and Dobson and Tompkinson (2012). However, the authors were not able to find any case studies specifically discussing using the SDGs to guide and design project/problem-based community-engaged learning. This case study built on the literature discussing the usefulness of project/problem-based community-engaged learning in teaching the SDGs, (Brundiers *et al.*, 2010; Konrad, *et at.*, 2021; Cörvers *et al.*, 2016), to inform the use of the SDGs in community partner selection, problem definition, and evaluation of the projects by students and their professor.

Research Questions

The primary research question for this study is:

- In what ways does project-based, community-engaged learning contribute to the development of key sustainability competencies?

An additional question asks:

- In what ways does using the United Nations Sustainable Development Goals to frame community-engaged learning contribute to awareness of the goals among students and community partners?

Design

A case study methodology was used to investigate the use of project and community-based learning pedagogical strategies for developing sustainability competencies within an undergraduate sustainability course. A case study is appropriate because the goal of the study is to examine the pedagogical strategies within the context of a real-world course (Yin, 2018, p. 15). The course context of the case includes using the United Nations Sustainable Development Goals to solicit and select community partners, as well as a framework for student reflection and instructor assessment. The structure of the course and the instructor herself cannot be separated from the use of specific pedagogical strategies.

Specifically, the pedagogy used a type of experiential learning informed by constructionist theory, project-based, community-engaged learning. The definition of project-based, community-engaged learning used in this study is learning by actively working with a community partner organization to provide tangible contributions towards addressing community partner needs. This definition was informed by Evans (2019, p. 5542) and Brassler and Dettmers (2017, p. 2), and aligns with the definition from the host university's Careers & Experience office which provided support for identifying and recruiting community partners for the course (Careers and Experience, no date, "Community-engaged Learning", para. 2).

Course Overview

The course in question is an intermediate level online, asynchronous course geared towards addressing sustainability challenges through project-based, community-engaged learning that ran in Fall 2021 at an undergraduate postsecondary institution in Alberta, Canada. Students are introduced to the idea of sustainability competencies early in the course. The instructor then connects different activities and resources back to these competencies throughout the semester.

The course is interdisciplinary and open to all students regardless of program of study making it difficult to focus course content on a particular subject area. Thus, the focus is on the content-independent key sustainability competencies as identified by Wiek *et al.* (2011). Sustainability challenges are complex and subject to change (Le Grange, 2011); therefore, focusing on competencies better serves course learning objectives such as being able to "evaluate goals, approaches, requirements, and tradeoffs for sustainability projects" (Primary Author, 2021, p. 2). All learners, regardless of background and field of interest, can develop skills that enable them to participate in and lead current and future sustainability projects.

There is substantial evidence (Brundiers *et al.*, 2010; Barth, 2015; Konrad, *et al.,* 2020) that pedagogies of project-based learning, which incorporates problem-based approaches, and community-engaged learning, are effective for learning sustainability competencies (Cörvers *et al.*, 2016, p. 357; Konrad, *et al.*, 2021, p. 537). All other course activities are designed to support the successful development of projects for community partners while facilitating student learning, experience, and engagement.

The SDGs take a multifaceted perspective on sustainability including social, economic, environment, and cultural components. Thus, framing the call for community partners around the SDGs ensured that all projects could be situated within the broad context of sustainability. Community partners were recruited through the Career and Experiences Office at the institution. Potential partners responded to the posted call and submitted their desired topics/project area as well as identified applicable SDGs for their potential projects. The instructor and Career and Experiences staff then vetted the projects to ensure they would meet the requirements for the course in terms of scope, topic area, and final product. Table 2 identifies the focus of the community partner organizations, the target SDG(s) identified by the organization, and a brief description of the project.

Table 2: Community Partners, Target SDGs, and Project Description

Community Partner Focus Area	Target SDG(s)	Project Description
Municipal Airshed Monitoring and Education	3. Good Health and Well-Being 13. Climate Action 17. Partnerships for the Goals	Development of social media campaign connecting air quality to the SDGs
Rural Airshed Monitoring and Education	3. Good Health and Well-Being 17. Partnerships for the Goals	Development of educational brochure connecting air quality to the SDGs
Anti-Racism Education in Rural Area	10. Reduced Inequalities 16. Peace, Justice and Strong Institutions 17. Partnerships for the Goals	Development of community resource kit to promote discussion of and engagement with anti-racist practices
Agricultural Research Organization	2. Zero Hunger 3. Good Health and Well-Being 12. Responsible Consumption and Production 13. Climate Action 15. Life on Land	Research report on agricultural practices to improve soil carbon sequestration
Adult Literacy Organization	1. No Poverty 4. Quality Education 8. Decent Work and Economic Growth 10. Reduced Inequalities	Promotional video connecting employment and business outcomes to increased adult literacy
Municipal Organization Focused on Large-Scale Events	12. Responsible Consumption and Production 17. Partnerships for the Goals	Research report on integrating social justice considerations into procurement policies
	12. Responsible Consumption and Production	Research report on improving waste diversion rates from large-scale events

Another significant characteristic of the course is the use of specifications grading for assessment. This is a form of mastery grading and is, therefore, better suited to the assessment of competencies (Nilson, 2014). Rather than students earning partial points on assessments, all assessments are graded as complete/revisions needed. This ensures that all students who earn a passing grade in the course have reached base levels of competency (Nilson, 2014). This contributes to the real-life connections provided by the community-engaged learning by replicating professional work requirements. As a result, it is likely that more students were able to improve their competencies than may have occurred in a traditionally graded course. Indeed, this has been examined in an introductory sustainability course and shown to be the case (Wasnieski, *et al*. 2021).

Consent and Anonymity

Students enrolled in the sustainability course were asked to consent to participate in the research. Consent information was collected by the co-investigator and was not shared with the primary author and course instructor until after the appeals period following the submission of the final grades in the course.

Data Collection

In their review of the sustainability competencies assessment literature Redman *et al.* (2021) identify eight dominant approaches. They recommend combining assessment tools "to address the shortcomings of any particular assessment tool" (Redman *et al.*, 2021, p. 127). This triangulation of multiple sources of evidence is also described by Yin (2018) as a fundamental feature of case study research. As a result, this study used a mixed-method approach drawing on three areas of data collection: scaled self-assessment, performance observation, and regular course work (Redman *et al.*, 2021). Data collection occurred throughout the Fall 2021 semester.

Scaled self-assessment

Scaled self-assessment asks students to reflect on their own skills, ability, and knowledge, and rank themselves on a Likert scale. This is a common method for assessing sustainability competencies (Redman *et al.*, 2021). The survey instrument in this study was adapted from Molderez and Fonseca (2018) who used the tool following participation in a service-learning project and real-world experience. The tool was adapted by rewording items to allow for a pre- and post-test condition to address a limitation identified by Molderez and Fonseca (2018). One item was removed as it was not applicable to the current case. The questionnaire is based on the competencies identified by Wiek *et al.* (2011) with each competency represented by multiple statements. For each statement, students rated their agreement on a five-point Likert scale rating. Students also had the option of selecting 0 for "no experience."

Performance Observation

The engagement of community partners in the course provided the opportunity to include performance observation in this project. This was limited because the community partners were not necessarily familiar with sustainability competencies and covering this concept is beyond the scope of this study. However, as professionals working in fields that are related to the United Nations Sustainable Development Goals, they are familiar with the skills and attributes that contribute to their work. Thus, partners were asked generally if they noticed skills, activities, or competencies that are relevant to sustainable development. This data is not specific to individual students.

Regular Course Work

Regular course work is the least used method in assessing sustainability competencies (Redman *et al.*, 2020). This may be a result of course work that typically focuses on learning outcomes rather than competencies. The use of specifications grading in the current course, as well as the development of final projects for community partners, facilitates a focus on outputs in this course. Therefore, the regular course work is well positioned to provide evidence of competence.

Analysis

R (version 4.1.2) was used for the statistical analysis of the self-assessments. Each of the five competencies was analyzed individually and combined. Prior to the model fitting process, descriptive statistics (mean, standard deviation, median and interquartile range of scores before and after taking the course) were computed. A series of Wilcoxon signed-rank non-parametric tests were conducted to assess whether there was a significant improvement in the median competencies. Due to a low sample size, individual items from the questionnaire were not analyzed separately.

In both qualitative and case study research, it is generally recommended that the researcher begins qualitative data analysis while still collecting data (Merriam and Tisdell, 2016; Yin, 2018). Informal analysis of student work was done throughout the period of data collection to adapt the course to the needs of the students. This led the researchers towards the development of initial codes apparent in student work. These codes were then formalized and sorted into categories and then associated with the most applicable competency following the completion of the course. This final process was based on the material from students who had consented to participate in the research only; however, the original codes were all represented within this sample. The formation of categories followed an inductive process as described by Merriam and Tisdell (2016). Dedoose (version XXXX) was used to support the coding and analysis of qualitative data.

Findings and Discussion

Demographics

Participants were students enrolled in an intermediate course on sustainability challenges at an undergraduate university. Twenty-eight students consented to have their course work included

as part of this research study. Base demographic data was collected. Most students in the course used she/her pronouns. A complete breakdown is found in Figure 1.

Students were enrolled in several different programs while taking this elective course. Figure 2 shows the breakdown by degree. Bachelor of Commerce is the highest number. The Other category includes Bachelor of Science in Nursing, Bachelor of Design, Open Studies, and Certificate of Achievement in Sustainability.

Due to an administrative error, the prerequisite course was missed for the 2021/2022 year. As a result, some students did not have the prerequisite. This data is shown in Figure 3.
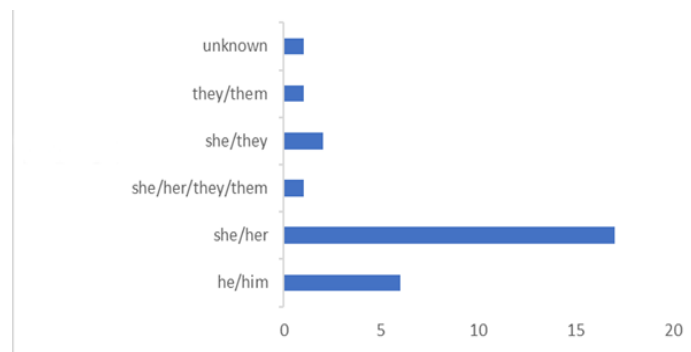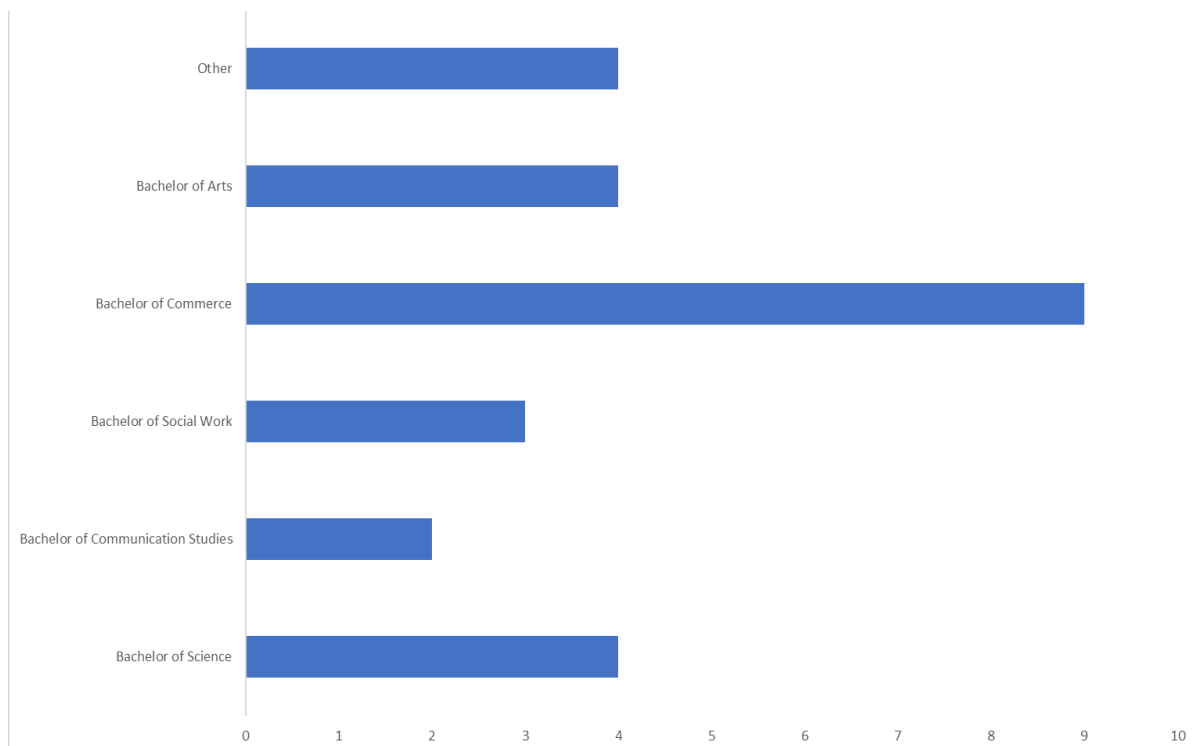

Figure 1. Student Pronouns
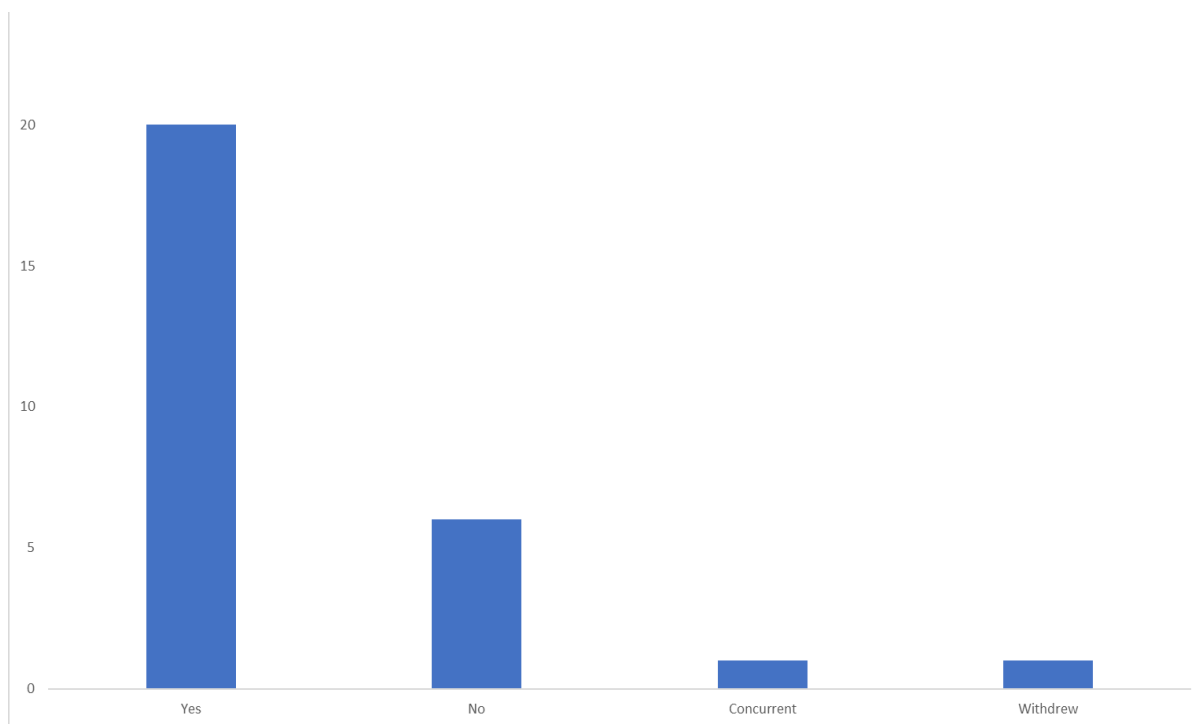
Figure 2. Student Program of Study

Figure 3. Prerequisite Course Completed

Developing Sustainability Competencies

This research presents the case study regarding the role of project-based and community-engaged learning in developing sustainability competencies. In addition, the impact of using the United Nations Sustainable Development Goals as the framework for engaging the community partners on student and partner understanding and capacity to act on the goals was investigated.

The sustainability competencies were based on Wiek *et al.* (2011). Redman and Wiek (2021) state that "the key competencies are *not* compiled as a *list* to select from" (p. 5). This matched the experience of the instructor in the course. While there were certain activities, resources, or projects that leaned towards specific competencies, it is difficult to tease all the different elements apart, nor should this be the goal. In what follows, the sustainability competencies, the opportunities to develop these competencies, and the evidence of that development, are separated, but the authors acknowledge that this is done to support readability and understanding rather than to represent the reality.

Pre and Post Self-Assessment of Sustainability Competencies

Twenty of the twenty-eight students completed both the pre and post self-assessment. The mean overall score of all 20 students increased from 104.6 (SD = 16.3) before to 118.1 (SD =16.4) after taking the course. As summarized in Table 3, the median scores for each of the five competencies also increased from before to after the course. Wilcoxon signed-rank tests demonstrated statistically significant improvements for all competencies based on a standard p-value of 0.05: interpersonal (W = 118, p = .0005) systems thinking (W = 173.5, p = .0055), anticipatory thinking (W = 168, p = .00171), normative thinking (W= 153, p = .00015), and strategic thinking (W = 57, p = .01561) and overall scores (W = 163.5, p = .00037).

Table 3. Comparison of Self-assessment Scores Before and After Taking the Sustainability Course

Competencies	Pre M $\pm$ SD	Post M $\pm$ SD	Pre Mdn $\pm$ IQR	Post Mdn $\pm$ IQR	W	P-value
Interpersonal	25.7$\pm$2.74	27.9$\pm$2.22	25.5$\pm$4.0	28.0$\pm$4.0	118	0.00050***
Systems thinking	30.7$\pm$6.22	35.9$\pm$3.84	31.5$\pm$9.5	37.0$\pm$4.25	173.5	0.00550**
Anticipatory thinking	18.5$\pm$ 3.52	21.4$\pm$3.39	18.5$\pm$5.25	21.5$\pm$6.0	168	0.00171**
Normative thinking	6.50$\pm$ 2.40	9.00$\pm$0.86	7.0$\pm$2.5	9.0$\pm$2.0	153	0.00015***
Strategic thinking	8.65$\pm$1.23	9.30$\pm$0.92	8.5$\pm$2.0	10.0$\pm$2.0	57	0.01561*
Overall	104.6$\pm$16.3	118.1$\pm$16.4	107.5$\pm$22.3	123.0$\pm$23.8	163.5	0.00037***

Note. M = mean, SD = standard deviation Mdn = median, IQR = Interquartile Range, W = Wilcoxon signed-rank test statistic. Significance cut-offs: * p <.05, **p<.01, ***p<.001

Self-assessment in this course was not simply a tool to measure competency development on behalf of the researchers. Self-assessment was included within the framework of the course to support what has been referred to as sustainable assessment (Boud and Soler, 2016). Within the context of sustainable assessment, assessment is viewed as one more tool that contributes to preparing students to be life-long learners after they leave formal education (Boud and Falchikov, 2007). Redman and Wiek (2021) critique the overreliance on self-assessment of competence based on questions of validity of self-assessments. However, self-assessment was framed to

students within the context of self-reflection to enable future learning and growth (Tamir, 1999). This was evident in student work. For example, Participant 14 stated:

The sustainability competencies really helped when it came to self-awareness within a group. Understanding my own strengths and weaknesses before beginning the project gave me a layout of my best qualities, I know I can contribute, and my worst ones that I can develop.

One student even recognized their own challenges with self-assessment:

Learning and developing sustainability competencies are a good reminder of how many factors can contribute to the success of a project. Self-assessment is not something that I'm good at, but it is valuable to take stock of personal strengths and areas for improvement. It's a good reminder that if we don't recognize our weaknesses, we can't improve them. (Participant 23)

The pre-self-assessment also contributed to helping students think about the breadth of sustainability challenges. As Participant 21 stated:

I believe the competencies in the surveys helped me consider what is involved in approaching sustainability from a social perspective. This helped me to consider where I am at regarding these competencies, and what I have yet to work on.

Upon reflection, I can see how the community partner projects helped to develop my skills in these competencies and solidify skills that I already had, such as leadership, communication skills, and thinking holistically about how our project can affect sustainability.

Thus, while we should be cautious in drawing conclusions based solely on the use of self-assessment, it is an important tool in sustainability education. It can support learners in becoming life-long learners who can adapt and grow in the face of changing sustainability challenges. This is summed up by Participant 3:

It gives us an overall understanding of where we are right now and how competent we are for certain projects. It helps us develop our weaknesses and also gives us awareness of what are our strengths so we understand what role we can take in the future sustainability projects and also how to overcome certain challenges.

Community-Engaged Learning and Sustainability Competencies

Redman and Wiek (2021) argue that all competencies need to be addressed and developed together for students to become "change agents" (p. 5). The quantitative results indicate that this has occurred within the context of the course in this study, as all competencies show significant improvement in the self-assessment. However, a key feature of this study is the triangulation of the self-assessment with the course work of the students, as examined by the instructor. Therefore, the self-assessed competencies will be discussed in relation to the course and specifically the community partner projects in the following sections.

Interpersonal

One of the characteristics of the present course is the diversity of the students: the course is an elective open to students from all faculties, as well as open studies students (those not registered in a program). As a result, the course offers an opportunity to work with more diverse teams than is offered in a discipline specific course. The community partner project forms the basis of the collaboration among students in the course. In other words, the team comes together to achieve a common goal based on their common interest in sustainability rather than their focus on earning a specific credential. This collaborative and interdisciplinary approach to advancing sustainability is fundamental to the demonstration of interpersonal competence (Redman and Wiek, 2021).

Two items of coursework were analyzed by the instructor to identify the development of interpersonal competence: group statements about collaborative work and individual summary statements regarding a round table activity. In the round table activity students presented their community partner projects with peers from different projects and collected feedback from and provided feedback to each other. Table 4 highlights examples of evidence that students developed interpersonal competence.

Students were asked to identify what they learned that they believed would have the biggest impact on their future decisions and options. Interpersonal was mentioned by 11 of 28 students, second only to systems thinking in terms of frequency. This growth was also reflected in the self-assessment data ($W=118$, $p<0.00050$). Students commented that they learned to look at diversity and disagreement as positives that can contribute to a more sustainable future. For example, participant 14 stated:

I've learnt that when people disagree, they do so because of their past situations, upbrings (sic), and everything that shaped them into the person they are today. Instead of turning it into a battle of who agrees and who disagrees, perhaps we should make a plan for a better future for everyone, and have everyone's voices heard so we can use every perspective and every angle to help us achieve our goals.

This statement illustrates how the student was able to approach disagreement as an opportunity rather than a challenge, which demonstrates interpersonal competence. Further, they indicated that this was an area of growth. This is in-line with what Konrad, *et al.*, (2021) found about the value of project-based learning for developing interpersonal competence.

Table 4. Student Examples and Instructor Analysis of Statements Indicating Development of Interpersonal Competence

Participant/ Group	Example	Instructor Analysis
Soil Carbon sequestration in Agriculture	Group statement about working collaboratively to create an interdisciplinary systems map: "each of our disciplines came together to bring ideas that may have been overlooked initially. We were able to discuss concepts and get a deeper understanding of the interconnections between elements. We cooperated to refine our map and disregard sections that we agreed did not contribute relevant details to our project."	Students demonstrated key skills for interpersonal competence such as "fostering self-efficacy for the self and others" (Evans, 2019, p. 5534). This is demonstrated by acknowledging that each person brought important ideas to the group and through discussion everyone deepened their understanding of the issues related to the challenge they were addressing
Participant 12	Round table summary: student reflected on the importance of thinking about who the audience is for their project and how that shapes what and how they write their report.	Student demonstrates awareness of the diversity of stakeholders in their project. The organization was looking for technical information that they could use to provide support to their stakeholders. As a result, the student reflected that the organization itself was the stakeholder that they needed to focus on, but that the other stakeholders should not be forgotten.
Participant 1	Round table summary: student described their thought process in re-evaluating the social media posts they had created for their organization. They discussed working on finding the balance between providing information, encouraging viewers to want to learn more, and engaging people with the posts.	Student demonstrates growing awareness of different potential audiences or stakeholders and working on providing options for people to engage at different levels.

Systems Thinking

Systems thinking was the most frequently identified learning that students thought would impact their future with 13 of 28 students mentioning it. However, systems thinking, while significant (W=173.5, p < 0.00550), was slightly lower than some of the other competencies with regards to the improvement throughout the course. The most likely explanation for this is that the 20 students who had completed the prerequisite course had all been exposed to systems thinking previously. Therefore, they likely had greater familiarity and comfort with the statements during the pre-self-assessment. This was not analyzed due to the small sample size.

Overall, the students stated that learning about interconnections and the importance of including other perspectives, which also touches on interpersonal competence, was something that greatly influenced their outlook. For example, Participant 10 stated:

I think that one of the biggest contributions of learning and developing sustainability competencies is my ability to now look at the bigger picture when taking on future sustainability projects and challenges. But when I say bigger picture, I mean the system I am working on as a whole, not just the end product I would want to get to, but how things are connected (like in systems mapping), and how each individual element in a project can have a specific effect on something else, whether that be an environmental effect or a societal or cultural effect.

Students create and submit systems maps individually based on the challenge their community partner was aiming to address (e.g., adult literacy, racism in rural environments, carbon sequestration through agricultural practices). If required, students completed revisions on their individual maps based on feedback and resubmitted. This ensured that students reached a base level of competency with both systems mapping and systems thinking in general. A sample student map is pictured in Figure 4.

RACIAL INEQUALITY - SYSTEMS MAP

Figure 4. Sample Individual Systems Map Examining Racism in a Rural Environment (Student 2)

The systems map assignment requires students to identify and describe feedback loops, leverage points, and the system's purpose. Students often struggle with feedback loops because the loops challenge the linear thinking that they are used to. Students are generally able to identify a causal relationship between elements, x leads to y leads to z. But they have trouble identifying how z impacts x. For example, student 15 initially described "the more reusable products, the better the environment" as a reinforcing feedback loop. The student identified the loop as reinforcing because both elements changed in the same direction.

The purpose is also challenging for students. Many students start thinking about the purpose of the system as the purpose for the organization, often summarizing the organization's mission statement as the purpose.

However, because the maps are based on a particular issue from an organization, observations of the organization enable students to better understand the system and systems mapping. For example, instructor guidance provided to the student regarding the feedback loop above encouraged them to think about how having a cleaner event space could influence event organizers' waste policies regarding reusable products. As a result, the student was able to revise their understanding about how the context, the environment, could influence policy regarding event materials

Similarly in identifying the purpose of the system, feedback encouraged reflection regarding what created a need for the organization. Therefore, students started to realize that the reason the

organizations existed was because the system was leading to circumstances that nobody wanted such as illiteracy, poverty, or climate change (Meadows, 2008, p. 15).
Example statements demonstrating systems competence are shown in Table 5.

Table 5. Student Examples and Instructor Analysis of Statements Indicating Development of Systems Thinking Competence

Participant	Example	Instructor Analysis
1	Leverage Point: *Alberta capital residences are directly affected by air quality. They also are able to influence policy and decision making by voting in policy makers with goals to create better air quality. Can put pressure on governments and NGO's to fund more research therefore educating more people*	Student demonstrates awareness that leverage points need to be able to impact large sections of a system in order to be effective
2	Purpose: *The perpetuation of racial inequality in … communities*	Student demonstrates awareness that systems can manifest purposes that are unintended by human actors in the system
13	Feedback loop: *If investments (by individuals, the government or the industry) increase, the economy is going to grow. As a consequence, more funds are available to individuals, the government and the industry, to invest more, which intensifies economic growth, leading to even more funds available to invest*	Student demonstrates awareness that a feedback loop must feedback, it is not a linear relationship

Following the completion of the individual systems map, students collaborated with their group members for their community partner project to develop a unified systems map. Figure 5 is an example team map.
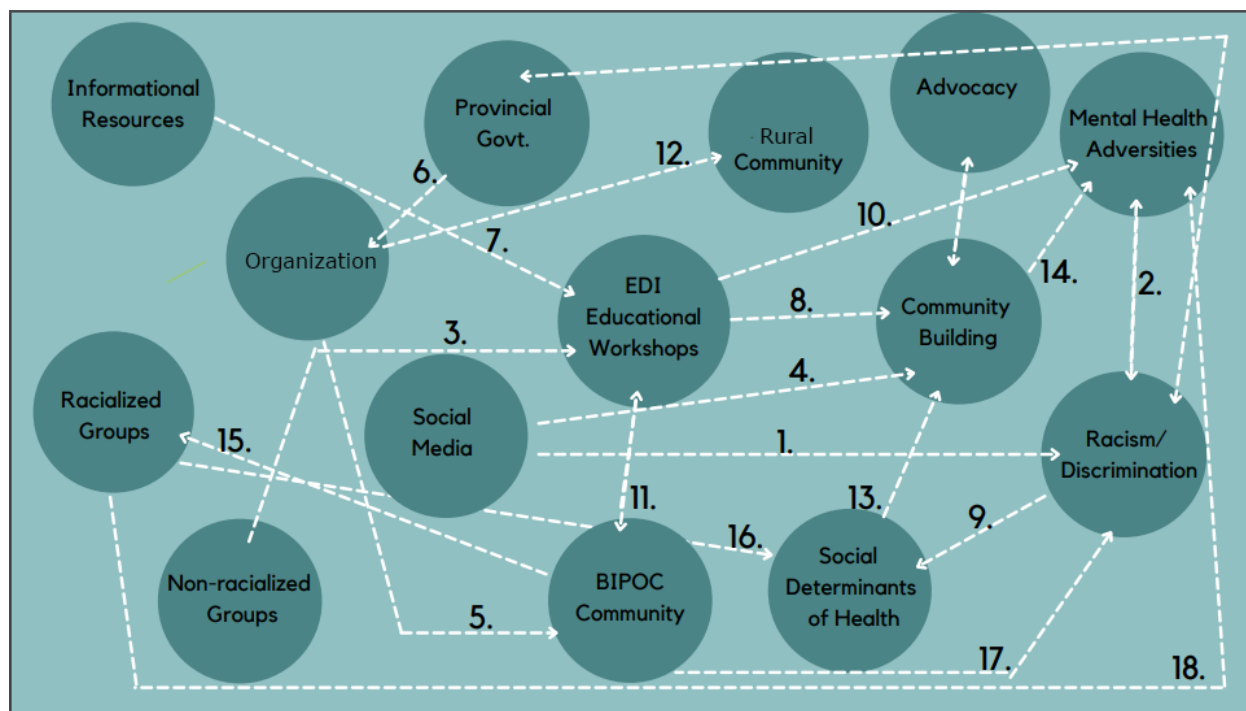
Figure 5. Team Constructed Systems Map Examining Racism in a Rural Environment

The numbers on the map describe the specific interconnections between the elements. Sample interconnections include:

> 1. Social media - displays/hosts - racial behaviours

> 7. Informational resources - improve - EDI educational Workshops

> 10. EDI educational workshops - bring awareness to - Mental Health Adversities

Comparing the individual and team maps revealed improved understanding of the examined system. This occurred through the inclusion of additional perspectives, increased awareness of individual biases, and negotiation of what to include in the team map. These factors were described by students in all seven teams. For example, Student 28 stated:

Throughout the course, I discovered that connecting with others in the course contributed to meaningful learning…I learned more about the different interdisciplinary approaches, elements, and ideas related to the issue or problem faced by [the organization]; this contributed to my development and learning process greatly… Because the group was diverse and knowledgeable in our own areas, it helped me to envision sustainability from many different lenses overall.

Another common statement was the need to understand the logic or rationale behind individual choices before they could agree on a common map. This corresponds to research regarding the impact of peer learning. In peer learning, students share knowledge, ideas, and experience in a

non-hierarchical relationship (Boud, 2001). Peer learning within the project groups cannot be separated from the impacts of project-based and community-engaged learning in the current study. The process of working together supported groups in defining the boundaries of the system, which is described by Evans (2019, p. 5533) as a key skill for systems competence.

From the instructor's perspective, having students negotiate the systems map demonstrates both interpersonal and systems thinking competence. Successful groups explain the assumptions underlying their individual maps and then negotiate the group map. While students often start their individual maps by identifying the elements (the circles in the two examples above), they find this process doesn't work when moving to the collaborative map because they realize how many assumptions and decisions underlie their elements that they were not aware of at the time of construction. Through this process, the students develop many of the systems related knowledges and skills that Evans (2019, p. 5533) identified including "understanding issues of scale and complexity", "understanding that systems are constructs and that different people may delineate and describe systems differently", and reflexivity. Similarly, Wiek *et al.* (2011, p. 207) state that systems thinking competence includes "comprehending, empirically verifying, and articulating [system] structure, key components, and dynamics". Further, within interpersonal competence students developed effective group discussion techniques, conveyed insights, and practiced active and deep listening (Evans, 2019). This was done to engage in problem solving as they developed a common systems map.

Anticipatory

Anticipatory competence is the most difficult competency to tie specifically to the community engaged learning opportunity in the course, although it was significant for the course overall (W=168, p < 0.00171). All students who mentioned anticipatory thinking as their most important takeaway (five of 28 students) referred to the reading "Other worlds are possible" (Weston, 2012). This chapter introduces requirements for sustainability that encourage anticipatory thinking, including believing that changing the system is possible (pp. 13-17), that new scales are required to measure good done rather than harm not done (pp. 17-21), and that sustainability, must be celebrated (pp. 24-28). As in all case study research, the contextual conditions of the case can't be separated (Yin, 2018). Therefore, it is possible that this reading, rather than the project-based, community-engaged learning, was the largest contributor to anticipatory competence amongst students. This will require further research to investigate.

The restrictions of a semester-based course potentially hindered the development of anticipatory thinking within the community-engaged learning projects. Community partners were asked to identify potential projects for students as part of their initial submission of interest. As a result, the students were less engaged in anticipating or envisioning future states. However, the process of brainstorming different ideas for their projects and weighing the challenges and opportunities of each option before proposing the final direction for the project is evidence of anticipatory thinking. Therefore, while the projects themselves may not be clearly connected to the development of anticipatory thinking, students did acknowledge this process through statements such as the following from participant 10.

Another way that developing sustainability competencies contributes to my future ability to take on sustainability projects is that I am able to work with a group to collectively create a sustainable vision for a project. By doing so, I know now how to work together to look at many different options to figure out which one is more sustainable. I can look at these different opinions and ideas from people and help to critically think about a direction to go.

Normative

Normative competence was not mentioned by any of the students as a key takeaway from the course and yet it showed a high level of significance in the self-assessment (W=153, p < 0.00015). Both statements in the self-assessment directly connect to the course pedagogies: "I am able to compare and contrast several alternatives for a project" and "I am able to collectively create and craft sustainability visions for a project". It is possible that this latter statement was reflected in the impact of interpersonal skills that many students did comment on, while the former may have been connected to anticipatory thinking by students. This again illustrates the difficulty of disentangling the different competencies (Redman and Wiek, 2021).

The process engaging with the normative competence within the context of the community-engaged learning projects was two-fold: First, the students, through the process of systems mapping identified, reconciled, and negotiated their individual perspectives on the current system. Second, they negotiated with the community partner to take the values, principles, goals, and targets of the partner and their stakeholders or participants into account. For example, industry stakeholders within the air quality monitoring organizations had to be considered during project development. For example, one of the Twitter posts the group developed focused on SDG 8: Decent Work and Economic Growth. In the thread they describe how air quality impacts many factors like well-being and agriculture that will impact economic growth (Alberta Capital Airshed, 2021).

The group working with an anti-racism organization in a rural context included text that demonstrated normative competence throughout their project. For example, at the start of one activity in the anti-racism activity kit they developed, they stated "There are no wrong answers in this game. It is about exploration and keeping an open mind. Some of the questions might feel uncomfortable, but they are there to encourage learning." This illustrates awareness of the current state of these discussions, but still encourages the importance of having the discussion.

Strategic

Strategic competence had the lowest significance of the five competencies. Two statements were attributed to this competence: "I am able to learn new skills and connect them to my professional goals/plans" and "I am able to see real world situations and relationships". Although we did not analyze these two items separately due to the small sample size, the difference in the pre and post assessment means for these two items is quite variable. For the former item, the mean on the pre-assessment was 4.5, while the post assessment was 4.65. The latter statement had a

larger change in mean from 4.15 (pre) to 4.65 (post). This may be explained because the students are likely pursuing undergraduate education with the goal of learning new skills and connecting them to their professional goals and plans (Nadelson *et al.*, 2013). As a result, this experience was not unique to this course.

Several of the projects were specifically targeting strategic competence in that they provided guidance and research on how the community partner organizations could move towards greater sustainability. For example, one group conducted a literature review for an agricultural organization on strategies and practices to increase rates of soil carbon storage. They also included a cost-benefit analysis to support farmers in incorporating sustainable practices. Another group examined and created a guidebook for an organization looking to improve waste diversion rates at large scale events. They broke their recommendations down into immediate, ongoing, and long-term categories to facilitate both immediate action and future goal setting. These examples illustrate that students demonstrated strategic competence within their projects.

Community Partner Feedback on Competency

The partners were not introduced to the five key sustainability competencies. As a result, the community partners who provided feedback (two of six accounting for three projects) provided general feedback relating to what sustainability related skills, activities, or competencies they witnessed. Both partners that provided feedback mentioned research and communication, in addition collaboration and planning were mentioned once each. These skills all fall within what Redman and Wiek (2021) identify as general and professional competencies because they are used in many different fields. In other words, they do not apply to sustainability more than other areas. However, with the small sample size, it is difficult to draw conclusions regarding these observations.

Community Partner Projects and the SDGs

Sustainability encompasses multiple domains including economics, environment, social justice, and cultural vitality. However, it is often viewed through a much narrower lens (Fisher and McAdams, 2015). The SDGs, when taken together, illustrate the broad requirements of sustainability (Leal Filho *et al.*, 2019). The instructor, with support from the Careers and Experience office at the host institution, used the UN Sustainable Development Goals to convey the broader understanding of sustainability to potential community partners. While all community partner projects were related to at least one SDG, the integration of the SDGs ranged from direct to indirect as shown in Table 6.

Table 6. Project Descriptions and SDG Connections

Project Description	Connection to SDGs
Social media posts (Twitter and Instagram) highlighting the relationship between	Direct: focused on educating organization followers on both air quality and the SDGs.

different SDGs and air quality	Covered multiple SDGs
Brochure highlighting the relationship between different SDGs and air quality	Direct: focused on educating organization followers on both air quality and the SDGs. Covered multiple SDGs
Anti-racism kit including activities and resources to support anti-racism education and ongoing engagement within rural communities that are predominantly white	Indirect: The SDGs are not mentioned within the project; however, students considered the following goals: SDG 4: Quality Education; SDG 10: Reduced Inequalities; and SDG 17: Partnership for the Goals.
Video for community employers about the benefits of adult literacy programs in supporting worker engagement, productivity, and skills building	Indirect: focus is on how access to adult literacy programs improves equal access to SDG 4: Quality Education. The project also indirectly impacts SDG 8: Decent work and economic growth and SDG 10: Reduced Inequalities.
Research report on agricultural methods to increase carbon sequestration in soils	Direct: carbon sequestration and agricultural practices are essential to multiple SDGs: Goal 2: Zero hunger; Goal 3: Good health and well-being; Goal 12: Responsible consumption and production; Goal 13: Climate action; and Goal 15: Life on land.
Research report on waste management at major events: Strategies to increase waste diversion	Direct: specific strategies for waste reduction target Goal 12: Responsible consumption and production.
Research report on best practices in social procurement policies	Direct: social procurement practices are connected to SDG 12: Responsible consumption and production and indirectly to SDG 8: Decent work and economic growth and SDG 13: Climate change.

At first, the SDGs were identified as a kind of shorthand to engage the breadth of community partners that the course required. However, it turned out to have a more significant impact. One of the community partners that provided feedback indicated that the project made their contribution to the goals more overt and concrete. Given that there is still limited awareness of the SDGs (United Nations Secretary-General, 2019), this demonstrates that community-engaged learning projects have the potential to contribute to awareness and possibly action on the goals.

Similarly, the second organization, which supervised two different projects, indicated that the projects contributed to not just their awareness of student groups to support their own

engagement with the SDGs through research, but they also identified that the organization itself can become a resource for their community in increasing engagement in the SDGs.

Additionally, two student projects focused on public awareness through communication of the relationship between the SDGs and air quality. While not quite the same approach, Manolis and Manoli (2021) found that awareness of the SDGs increased when student groups researched ecological projects that related to the SDGs and presented them within the capital city of the region at a sustainability related event.

The shaping of the call around the SDGs did support the engagement of a range of potential projects across all four domains of sustainability. However, additional research is required to determine the extent of the impact of the call on the community partners' future engagement with the SDGs.

Limitations

A case study approach is used when it is not possible to separate the goal of the study from the contextual factors of the case. This limits the generalizability of the research. However, the results support the use of project-based and community-based learning opportunities to contribute to the development of sustainability competencies. Small sample sizes also impact the generalizability of the research. However, as an exploratory case, this study supports future use and investigation of the SDGs as a framework for engaging community partners with sustainability education. It also supports the role of community-engaged learning to support increased engagement with the SDGs among community organizations. Finally, the inclusion of the three emerging competencies suggested in Brundiers *et al.* 2021 is an important element that needs to be investigated to determine the applicability of the pedagogical approaches used here in supporting development.

Implications

The results of the pre and post self-assessment combined with the instructor assessment in this case study generally supports the effectiveness of project-based, community-engaged pedagogical approaches to developing sustainability competencies. However, our results comparing student self-assessment of their learning on the different competencies, shows some variance from past findings. Trencher *et al.* (2018) report that all programs they looked at were less effective at developing anticipatory competence vs. other key sustainability competences, while practice-oriented programs were better at developing normative, strategic, and interpersonal competencies (p. 839-840). In this study, we also found that normative and interpersonal competencies were well developed but anticipatory or future-thinking competence was reported as being more substantially developed compared to strategic competence. Discussion of the results of self-assessment of anticipatory competence points to the contributions of a course reading. This provides some support for augmenting or balancing hands-on project/problem based and community-engaged learning with other forms of academic learning.

Given the lack of awareness generally of the SDGs (UN Secretary-General, 2019) and the common narrow understanding of sustainability (Fisher and McAdams, 2015), we have demonstrated that using the SDGs to frame project-based, community-engaged learning can contribute to greater awareness of the SDGs and the values that they encapsulate for students and community partners.

This case study adds to the literature around preparing students to be sustainability practitioners vs. researchers (Trencher *et al.*, 2018). The professional sustainability environment is likely as important to creating change as education that creates change makers. Cörvers *et al.* (2016, p. 352) found that sustainability professionals at the time were mainly focused on "climate change and energy issues". This professional focus has likely broadened and changed, so their views of important skills may have as well. Including sustainability professional's perspectives in analysis of future case studies in academia will also contribute information relevant to the implementation competency suggested by Brundiers *et al.* (2021, p. 21).

One future focus of research could be to reconnect with past students who have developed sustainability competencies through formal learning opportunities and assess how the competencies have contributed to their professional work. This would support the call made by Redman and Wiek (2021, p. 8) to test the sustainability competency framework "in real-world problem-solving settings".

Originality

This case study represents a unique context of an interdisciplinary undergraduate course on sustainability that incorporates a diverse mix of teaching, learning, and assessment pedagogies. Konrad *et al.* (2021, p. 536) identify a need for studies investigating the many influences on students in their learning, including their learning processes. In this case, the pedagogy and the assessment strategy were part of the student's learning process.

This study incorporates the SDGs not just as content to be learned by students, or in connection with the key sustainability competencies, but as a tool for selecting and educating community partners. This approach or information reporting on the effect of using this approach with community partners has not been found by the authors to be well represented in the literature on sustainability education.

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