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An Intentionally Designed Sustainability Course: Integrating Service-Learning and Community Engagement into Sustainability Education

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ABSTRACT: In this paper we offer an approach to sustainability-related education that can help students integrate the lessons they are learning in the classrooms to the type of real-world applications they will encounter in the workplace. We believe that by using our campus as a living-learning laboratory and engaging students in hands-on projects within a campus lab that directly contribute to one of their institution's leading sustainability initiatives, we can unlock the highest levels of educational achievement and student satisfaction. We describe our course as intentionally designed because we have developed it with a specific purpose that goes beyond the stated learning objectives. Our course not only addresses recognized institutional and course-level educational outcomes, but also uses a community engagement approach that also directly supports important aspects of an enterprise-wide Sustainability Strategic Plan. We present relevant literature, highlight the significance of our approach to sustainability education, and describe its impact at our institution and in the community. We then offer detailed descriptions of our course's activities, discuss lessons-learned and suggest future potential avenues of research and application. We hope this case study may prove to be an exemplar or a catalyst for other institutions of higher education as well as inspire further research aimed at improving sustainability education.

Keywords: Sustainability, sustainability education, service-learning, community engagement, strategic plan, institutions of higher education

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Disclaimer

"The views expressed in this article, book, or presentation are those of the author and do not necessarily reflect the official policy or position of the United States Air Force Academy, the Air Force, the Department of Defense, or the U.S. Government."

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Introduction

Sustainability is enjoying unprecedented attention across all sectors of the economy including higher education. There is also a concurrent emphasis in higher education on many different approaches to teaching sustainability (Bandy, 2011; Hurney, Nash, Hartman & Brantmeier, 2016; Natkin & Kolbe, 2016; Papenfuss et al., 2019; Roberts, 2013). Recognizing this, we present an example of how our institution addressed the significant topic of sustainability awareness and education. By using service-learning and community engagement, we aligned student projects throughout the institution and with a soon to be adopted United States Air Force Academy (USAFA) Sustainability Strategic Plan.

Sustainability has become a significant contemporary societal focus that has evolved far beyond its roots of meeting today's needs without compromising the needs of future generations (WCED, 1987). It has inspired many public and private sector organizations to modify their priorities, as well as transform how they view their operational environment, their internal governance, and even how they may be impacted and influenced by developing evolutionary societal changes (Scharmer, 2018; Senge & Sterman, 1992). Institutions of higher education (IHE) have embraced various pedagogies aimed at exposing students to the many different aspects of sustainability. These colleges and universities also strive to help students appreciate the impact of sustainability in their future professional lives. From this the field of Sustainability Science has evolved (Spangenberg, 2011).

Given that the field of Sustainability Science is inherently applied, we agree with Chawla (1999) and Otte (2016) that educating students about sustainability should ideally include an experiential, engaging, and hands-on approach. Similar to the Piedmont and Ponderosa sustainability education philosophies (Barlett & Chase, 2012; Eisen & Barlett, 2006), we feel sustainability in higher education can include curriculum, research, university operations, and the community that interacts directly or indirectly with the university. We expand on the typical curricular focus and instead seek to integrate all four of those aspects into one course directly serving the institution.

Using a predominately service-learning community engagement pedagogy as our foundation, we developed a class that not only addresses course and institutional learning objectives, but also provides direct input into an ongoing project to create our enterprise-wide USAFA Sustainability Strategic Plan. Our approach allows students to develop leadership skills while directly supporting one of our main core values of "service before self" (USAFA Core Values, 2024). Sustainability leaders must understand the interconnectedness of environmental, social, and economic systems and how changes in one area can impact others. Given the interdisciplinary nature of sustainability challenges, leaders need strong collaboration skills to work across sectors and engage diverse stakeholders, including governments, businesses, communities, not-for-profits, and NGOs.

Utilizing specific real-world class projects which are directly tied to supporting the development of our USAFA Sustainability Strategic Plan, enables our students to accomplish

course objectives, achieve metacognitive level learning, and increase satisfaction, while also helping to address a real-world on-going institutional requirement.

Our course entitled "Sustainability in Practice", demonstrates the goal congruence that is possible when relating classroom objectives with actual sustainability-related requirements. We hope our intentionally designed sustainability course with its service-learning community engagement approach, aligned directly with a major enterprise-wide sustainability activity, can be helpful to other IHEs as they develop their own courses and programs related to sustainability.

After a brief background on sustainability and a review of select education literature, we offer insight into the significance of sustainability at our institution followed by a description of the USAFA Sustainability Strategic Plan. We then provide details of our "Sustainability in Practice" course as a case study, and conclude with lessons learned, and suggestions for future study and consideration.

Background

Sustainability has become mainstream and a part of our contemporary lexicon; but diverse characterizations continue to emerge. These disparate definitions have developed in part because the concept of sustainability is evolving. Different sectors of society view sustainability through different lenses, and varying levels of stakeholder awareness exist. There is also a lack of uniformly accepted metrics to report the progress or success of sustainability-related performance (Kramer & Pfitzer, 2022). For example, one widely accepted sustainability framework states that three fundamental concepts underpin sustainability; society, the economy, and the environment —or people, profit, and the planet (Barber, Sicre, & Johnson, 2022).

Early sustainability frameworks in the business sector are often associated with Corporate Social Responsibility (CSR) (Dahlsrud, 2006). In general terms, CSR describes societal trends that recognize that companies should consider the environmental and social impacts. A related business oriented concept referred to Triple Bottom Line (TBL) emphasizes the need to focus on social and environmental impact rather than solely focusing on profit (Alhaddi, 2015). Recently, corporations have gravitated beyond CSR and TBL to the framework commonly referred to as ESG (Environmental, Social, and Governance), which is preferred by capital markets because it is more specific and measurable than some CSR or various other sustainability-related efforts. Companies and organizations are also known to inflate the success of their sustainability-related efforts in what had widely become known as "greenwashing" (de Freitas Netto, Sobral, Ribeiro, & da Luz Soares, 2020).

Focusing on ESG performance which aims at creating value for all stakeholders has steered attention away from predominately short-term financial objectives to more measurable long-term strategic goals (Whelan & Fink, 2016). This strategic and multi-disciplinary orientation has motivated companies and organizations around the world to integrate sustainability into their strategic planning; and in part has motivated our institution to create a

USAFA Sustainability Strategic Plan as well as to intentionally teach sustainability to our students.

The nearly 4000 students at the United States Air Force Academy (USAFA) pursue a rigorous liberal arts education and military training to become officers in the United States Air and Space Forces. They come from diverse backgrounds and represent various regions of the United States. These students are highly motivated, disciplined, and dedicated to serving their country. They undergo a comprehensive academic curriculum, physical training, and leadership development programs during their time at the Academy. Additionally, they adhere to a strict code of conduct and character development, reflecting the core values of integrity, service, and excellence.

For our "Sustainability in Practice" course, we define sustainability in the spirit found in the Report to the World Commission on Environment and Development "Our Common Future", frequently referred to as the Brundtland Report, as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987).

The Brundtland Report was also an early reference and warning that the evolving environmental crisis presents a threat to all countries' national security (WCED, 1987). This was significant for the development of our course for our institution because we are directly associated with the United States Department of Defense (DoD). When the DoD labelled climate change a threat to national security, they inexorably moved toward integrating climate-related impacts into their strategic planning and budgeting processes. They also focused on the national security implications of climate change, and began integrating climate-related impacts into their planning cycles (Department of Defense, June 29, 2015). The concurrent sustainability movement in society at large provided different frameworks upon which the DoD could potentially address sustainability-related items such as climate change. The result is a United States Air Force (USAF) -wide comprehensive Climate Action Plan that defines a prioritized blueprint to preserve operational capability, increase resiliency, and help mitigate future climate impacts (Department of the Air Force, 2022). Because of this, it is crucial that our cadets be well versed in sustainability science and ready to tackle the concerns sustainability issues generate.

Select Literature Review of the Educational Landscape

Over the last several decades the higher education landscape has transitioned away from instruction and toward learning (Barr & Tagg, 1995). Moving from training to learning places greater emphasis on empowering learners to take ownership of their learning process. Learning-oriented approaches in sustainability education promote critical thinking and problem-solving skills. Shifting towards a learning-focused paradigm encourages the development of lifelong learning skills. Overall, the shift from training to learning in sustainability education empowers learners to become agents of change, equipped with the knowledge, skills, and mindset needed to address complex sustainability issues and create a more sustainable future.

Our course was intentionally designed with several learning and community engagement theories (Bandy, 2011) in mind to best address our institutional values, the needs of our students, and ultimately enhance the learning experience. We briefly review a sampling in this section.

Higher education pedagogies have different names, may be disciplinarily unique, and have common components. Some examples of educational approaches include; experiential learning (Kolb & Kolb, 2009; Reynolds & Vince, 2007; Specht, 1985), experience-based earning (Matsuo, Wong & Kee-hung, 2008), active learning (Lizzio & Wilson, 2004), service-learning (Salam et al., 2019), community engagement (Bandy, 2011); cooperative learning (Johnson, Johnson & Smith, 2014), transformative learning (Papenfuss et al., 2019), and collaborative learning (De Hei et al., 2015; Dillenbourg, 1999), to name a few. Emphasis on experiential and service-learning with community engagement was the spirit in which our "Sustainability in Practice" course was intentionally designed and offered.

In higher education, students are often recognized as being "intentional learners" who are better prepared to adapt to new environments, integrate knowledge from different sources and continue learning throughout their lives (Martin, Green, & Heppard, 2013). Also, teaching students to identify and take advantage of their own styles of learning, as well as recognize their weakness, helps to prepare them to address the complexities of the real-world they will encounter (Berhman & Levin, 1984) and is useful to solve the complex problems on which the field of sustainability science routinely focuses. The general approach often referred to as experiential learning (Beard & Wilson, 2006) has been an excellent pedagogy to address this transformation because it recognizes that people learn best from their own experiences (Hornyak, Green, & Heppard, 2013). Sulkowski et al. (2020), Browne et al. (2020), and Ely (2018) found that experiential learning was successful in facilitating sustainability education and this encouraged the intentional design of our course.

Our "Sustainability in Practice" course also builds on the closely related concept of active learning as related to students' motivation to engage in their studies in a meaningful way (Herrmann, 2013). Active learning is an effective pedagogy that emphasizes taking an active part in learning as opposed to passively listening (Prince, 2004). Active learning in sustainability courses involves engaging students in hands-on activities, discussions, projects, and real-world applications to deepen their understanding of sustainability concepts and foster critical thinking and problem-solving skills. Examples include service learning and volunteer projects, field studies, simulations, case studies, collaboration with design and innovation courses, and online projects allowing students to interact directly with possible sustainability partners. These types of active learning strategies in sustainability courses help to create dynamic and engaging learning experiences that prepare students to become change agents and sustainability champions in their community and beyond.

Active learning encourages valuable outcomes which are aligned with our stated educational outcomes such as improved communication, leadership, conflict resolution, and cooperation (Herrmann, 2013). Studies have credited active learning in STEM classes with better performance, greater diversity, more equity, and fewer withdrawals (O'Leary et al., 2020; Theobald et al., 2020). Significant for our course, MacVaugh and Norton (2012) and Claro and

Esteves (2021), successfully embraced introducing sustainability to students in higher education using active learning.

With this background, service-learning is the pedagogy that best describes the approach we intentionally took in developing our course. Service-learning, also referred to as community engagement (Bandy, 2011), is a type of experiential learning and active learning which provides opportunity for students to enhance their understanding of concepts and theories in practical environment by providing a service to meet a specific community requirement (Bandy, 2011; Salam et al., 2019). Service-learning is a recognized higher education pedagogy that directly influences students' academic, civic, and professional development (Stanton, Giles, & Cruz; 1999).

Perhaps because of the appeal of community engagement, some scholars, such as Papamarcos (2005) feel that service-learning represents perhaps the most effective teaching tool and it has been recognized as a high-impact educational practice by the American Association of Colleges and Universities (AAC&U) (Kuh, 2008). Further, community engagement-based service-learning activities integrated into curricula have many and diverse educational benefits (Bringle & Hatcher, 1996; Nejmeh, 2012). Examples of service-learning best practices and benefits are best viewed from different stakeholder perspectives. For example, for our course, as faculty collaborated closely with our community partners, the faculty were able to establish clear learning objectives that not only enhanced student understanding of course material, but also improved connection to the community. From the students' perspective, their hands-on learning experiences helped them connect service to academic content and gain leadership experience, as well as foster problem-solving, creativity, and innovation. Our community partners experienced tangible social impact through community engagement, and our students fostered a fresh perspective on innovation and problem-solving.

Numerous studies have examined best practices for service-learning from different stakeholder perspectives, including the faculty, the student, and the participating community partner as well as the perspectives of various different academic disciplines (Mason & Dunens, 2019). Some universities offer courses that implement a service-learning pedagogy that provides opportunities for students and community partners to work together on semester-long projects. Occasionally service-learning is equated to volunteerism or internship; but according to Ferrari and Chapman (2014) these activities are very different because service-learning is more focused on enhancing students' understanding of their theoretical knowledge as well as reflection on that experience.

We feel our "Sustainability in Practice" course leverages the positive aspects of experiential and service-learning community engagement pedagogies, while addressing an on-going actual real-world institutional requirement; the development of the USAFA Sustainability Strategic Plan. Simply put, we are suggesting directly tying in course projects to an institution's sustainability-related requirement. We feel the potential goal congruence between the learning aspirations of our students and the actual needs of a specific identifiable community partner, especially regarding a significant real-world tasks such as the development of a sustainability strategic plan, may be an exemplar for other IHEs to consider when developing sustainability-

related courses. An excellent source of examples and other related resources is AASHE's Case Study Library which contains hundreds of detailed case studies on a wide variety of higher education sustainability initiatives including faculty development programs, campus energy retrofits, and community partnerships (AASHE, 2024). It can be viewed at https://hub.aashe.org/browse/types/casestudy/.

Significance of Sustainability to USAFA

USAFA is not only committed to provide the best possible educational experience for its students, but it also has a keen interest in preparing them with the adaptive-capacity to best address the challenges that they will inevitably face while on active duty in the USAF and Space Force. This environment makes experiential hands-on learning particularly valuable pedagogy for meeting educational goals and outcomes. By the time students graduate and are commissioned as second lieutenants, they are expected to have acquired a combination of knowledge, skills, and abilities that they will need to succeed as airmen, guardians, and citizens (USAFA Mission and Vision, 2024). This has direct implications to the application of the "practice" aspect of our "Sustainability in Practice" course because students see first-hand how they are actually applying their work in a practical setting.

USAFA's academic program is woven into the broader fabric of its other major programs of character and leadership development, athletics, and airmanship (USAFA Outcomes, 2024). USAFA's nine Institutional Outcomes represent the characteristics graduates must have in order to be successful as they enter the USAF:

- Critical thinking
- Clear communication
- Scientific reasoning and the principles of science
- Application of engineering methods
- The human condition, cultures, and societies
- Ethics and respect for human dignity
- Leadership, teamwork, and org. management
- National security of the American republic
- Warrior ethos as airmen and citizens

(USAFA Outcomes, 2024)

The multi-disciplinary curriculum is designed to develop critical thinking skills, understand the human condition, culture and society and do this while respecting human dignity. In addition to these imposing goals, USAFA is highly engineering-orientated and our students are asked to apply principles of science, and engineering methods. In fact, USAFA considers harmonizing STEM (science, technology, engineering, and math) and the Liberal Arts as an element of what is referred to as the "Essence of USAFA" (Branum, April 6, 2014).

Kates describes sustainability science as transdisciplinary and as such links foundational knowledge from a variety of disciplines to address sustainability-related problems which need to be revisited over time (Kates et al., 2016). In their future professional lives, students from all disciplines will need to apply the principles of science to address societal implications of looming environmental challenges (Jabbour, 2010), and integrating sustainability education can be accomplished at almost all IHE (Stewart, 2010). But integrating sustainability-related courses and topics also presents challenges as well (Barber et al., 2014). For example, many schools may lack faculty members with expertise in sustainability-related topics. Some faculty members or administrators may be resistant to integrating sustainability into their curricula due to concerns about disrupting established teaching methods or perceptions of sustainability as a niche or peripheral topic. Finally, sustainability is inherently interdisciplinary, encompassing aspects of environmental science, social justice, economics, and ethics. Integrating into a curricula can be challenging due to institutional silos, lack of coordination, and insufficient support from the President or Chancellor. Our course would not have been possible without the involvement of USAFA's Sustainability Manager and the recognition by the Vice Dean that project-based learning is valuable.

Recognizing this, recently USAFA has begun integrating sustainability principles into existing courses as well as developing new sustainability-focused courses across four different academic departments. The Department of Civil and Environmental Engineering offers a course titled "Introduction to Sustainability" that is offered to all students as one of their advanced core classes and is also a required course for the Global Logistics Minor. The Department of Management offers a course in "Managerial Accounting" that includes a four-week module and case study on sustainability reporting from the accounting and finance perspective. Other elective courses include a "Sustainable Energy" course offered by the Department of Mechanical Engineering, and a "Humanitarian Engineering" course offered by Department of Civil and Environmental Engineering. This department also developed a Sustainability Minor and another sustainability-related course; a capstone course focused on conducting Life Cycle Analyses. Additionally, the Department of Economics and Geosciences is contributing multiple courses to the minor including "Economic Geography", "Cultural Geography", "Economics of Inequality", "Economics of Development and Conflict", among others. This department is also the lead on the "Sustainability in Practice" course which is the focus of this case study.

This "Sustainability in Practice" course incorporates an experiential, service-learning community engagement pedagogy. Service-Learning projects based course content enable students to take leadership on entire projects, but also specific portions of projects, all in service to an actual client; thus allowing them to develop leadership skills tied directly towards one of USAFA's core values of "service before self" (USAFA Core Values, 2024). Also, the iterative nature of developing deliverables for clients as part of the course enables students to progress and grow their technical and synthesis skills, as well as their written and oral communication abilities; this also addresses several specific educational outcomes. The structure of the course allows students to practice, make mistakes, learn from others, receive and digest feedback from multiple entities; predominately the professor and clients. We feel this approach ultimately improves not only their course deliverables but also themselves as individuals and leaders, and

better enables them to thrive and address an additional USAFA core value, "excellence in all we do" (USAFA Core Values, 2024). This approach is summarized in Figure 1.

Figure 1. Summary of our approach

USAFA Sustainability Strategic Plan

In an effort to align with DoD and USAF sustainability-related directives, policies, and activities, and to build upon USAFA's existing net-zero energy initiatives, USAFA's Superintendent, the equivalent to a Chancellor, directed the creation of an institution-wide Sustainability Strategic Planning Committee and identified a Sustainability Manager to craft a Sustainability Strategic Plan. USAFA adopted the Brundtland definition of Sustainability for its related efforts (WECD, 1987).

USAFA's Sustainability Vision is to "Set an example for the Air and Space Forces for sustainability practices; Educate and inspire current and future generations of Air Force leadership in sustainability; Demonstrate sustainability in operational excellence for all stakeholders and visitors" (USAFA Sustainability Strategic Plan - Draft, 2022).

The approach that the USAFA Sustainability Strategic Plan took was considered "actionable"; with Baseline Status, Policy Context, and Opportunities (USAFA Sustainability Strategic Plan -Draft, 2022). To ensure performance measurement, each planning area includes

targets that define the period in which the sustainability goal will be achieved; short-term (within 0-5 years); mid-term (5-10 years); and long-term (beyond 10 years). The plan contains Major Goals that outline the action areas USAFA targets to accomplish, Strategies that develop the actions and changes required to accomplish major goals, and example Metrics that detail the indicators that will help measure progress over time (USAFA Sustainability Strategic Plan -Draft, 2022).

The plan is organized into nine core planning areas, themselves categorized into three themes; Planet, People, and Place. The core planning areas are Energy, Water, Waste, Natural and Cultural Resources, Transportation, Planning and Design, Diversity and Inclusion, Education and Outreach, and Operations. The first three contribute to the Planet thematic grouping, the next three to the Place theme, and the last three to the People theme (Figure 2).

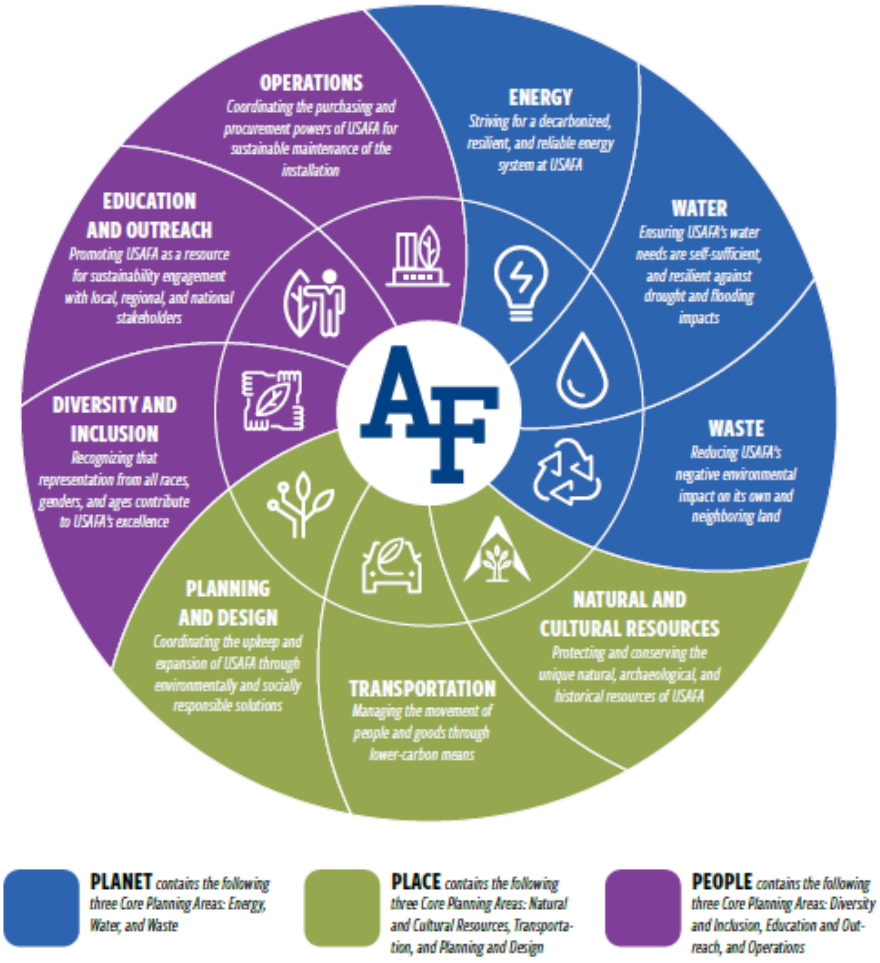

Figure 2. Nine Core Planning Areas of the USAFA Draft Strategic organized into three groupings: Planet, Place, People. From United States Air Force Academy (USAFA), Draft USAFA Sustainability Strategic Plan. (2022). Used with permission.

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The "Sustainability in Practice" Course

The USAFA Department of Economics and Geosciences intentionally designed, and offered the "Sustainability in Practice" course first as an experiment. The course continues to be offered as an elective. In its first iteration twenty-one students were divided into four groups each working on a specific "real-world" project for clients; in this case, the institution's Sustainability Manager, the U.S. Fish and Wildlife Service Officer on campus, and the City of Denver. The first half of the course consisted of exposure to foundational knowledge of sustainability principles, practices, and frameworks. The remainder of the course was dedicated to the service-learning aspect of addressing a community-based need. In future iterations of the course, devoting more time to the projects would be beneficial; however the class would then most likely need an "Introduction to Sustainability Science" pre-requisite.

In Table 1 we showcase several student projects as examples of completed student projects. These are then summarized below including a lessons-learned summary.

Project title	Client	Core Planning Area(s)
STARS Food and Waste Assessment	United States Air Force Academy (USAFA) Sustainability Manager	Waste
Game Day Basketball Recycling Competition	USAFA Sustainability Manager	Waste + Education and Outreach
Mapping Heat Vulnerability in Denver, CO	Executive Director of the Office of Climate Action, Sustainability and Resiliency for the City of Denver, Colorado	Education and Outreach
Mapping restoration areas around Monument Creek	United States Fish and Wildlife Service	Natural and Cultural Resources
Effective visualizations of urbanization and stormwater runoff in El Paso County, CO from 1985 to 2020	United States Fish and Wildlife Service	Natural and Cultural Resources + Education and Outreach
Visualizations of energy, water, and natural gas use at USAFA	USAFA Sustainability Manager and 10th Civil Engineering Squadron	Energy + Water
Virtual tour of USAFA sustainability features	USAFA Sustainability Manager	Education and Outreach
Developing educational materials to augment recycling efforts at USAFA	USAFA Sustainability Manager and Chief Environmental Officer	Waste + Education and Outreach

Table 1. Summary of the projects tackled as part of the Sustainability in Practice course at USAFA.

Project #1

The first project consisted of attempting to gather data for the Sustainability Tracking and Rating System (STARS) reporting. STARS is a widely used tool for relative performance measurement administered by the American Association of Sustainability in Higher Education (AASHE) (STARS, 2024). It is also used in higher education settings (Kmetz & Hackman, 2022). This team of students acquired institutional data to complete the "Food and Dining" as well as the "Waste" subcategories of the STARS report for USAFA. This project was selected because USAFA was experiencing difficulty in developing performance goals and metrics for the USAFA Sustainability Strategic Plan and required a means of measuring the effectiveness of various sustainability-related activities and proposals. It was determined that the STARS system could provide excellent, previously tested, and comparable benchmarks with what could be considered peer universities. This type of information would be pivotal in the success of many parts of the USAFA Sustainability Strategic Plan.

Consequently, USAFA became a first-time AASHE member and students examined the feasibility of using the STARS rating system and metrics to document baseline status and report on long-term sustainability endeavors at USAFA. They processed data into useable and relevant results, conducted gap analyses to identify areas where improvements would have the most impact, researched and presented the advantages and disadvantages of various options they research to improve the USAFA STARS scores in various subcategories. At the end of the course, findings were presented to the customer, USAFA's Sustainability Manager, with students defending and substantiating their recommendations.

Since STARS reporting at USAFA was new, the major lesson learned for this specific project was most of the project's efforts were to find the right individuals in the organization who had the necessary data and could provide it in a useful format. This was a difficult undertaking as the STARS reporting categories are established, yet some of the data needed was not currently being collected at USAFA. The sustainability manager had networked with local institutions to learn from their efforts in gathering data for STARS assessments. The Director of Sustainability from a local university gave a guest lecture in our course about her team's best efforts to fill out the two categories the USAFA team was attempting to complete. We used their efforts as a springboard for ours."

The students developed recommendations and recognized that active tracking of the necessary data over the subsequent year was needed. It was also determined to be crucial to have individual buy-in to these efforts as it would constitute more work for them. A clear commitment from institutional leadership would be needed to ensure that requests to collect such data was a requirement.

Project #2

For the second project, students participated in a nationwide recycling competition through the National Wildlife Federation's campus recycling program. USAFA's Sustainability Manager, served as the client for this project as well. The goals of this project were to promote recycling education in a fun and competitive manner while also increasing awareness of how to properly

recycle in the local community of El Paso County. The student team coordinated with the Sustainability Manager, as well as many individuals from the Athletic Department, Civil Engineering office, waste and custodial contractors and staff. This coordination was necessary to create an effective system designed to try to collect the maximum amount of recycling while mitigating or eliminating contamination. Posters and volunteers were strategically placed throughout a major athletic event – a basketball game, to promote competition and provide information as to what can be recycled.

The student team had a centrally located educational booth where participants could place what they thought was recyclable in the appropriate bins to win prizes; including T-shirts, stickers, and candy, donated by sponsors. This interactive booth helped dispel myths and misconceptions regarding recycling in a fun and engaging way. Trained volunteers were stationed next to each recycling and trash bin to instruct spectators on how to sort what they were discarding to eliminate contamination of recycling bins with unrecyclable items. At the end of the basketball game, all recyclables were collected, and the team ensured there was zero contamination by inspecting and sorting each bag before dumping it into recycling container. USAFA's waste hauler then collected the 200lbs of recyclables which was ranked 5th nationally in the "Game-Day Basketball Recycling" category. The students developed a manual on how to conduct future events and presented their project at an undergraduate research forum. This project contributed to advancing the USAFA Sustainability Strategic plan in that it was an example of how to institutionalize waste reduction and recycling, as well as increase knowledge and awareness of recycling efforts at the institution and in the local community.

The project also revealed issues with the recycling program at the basketball and hockey facilities. In particular, before this project, custodians were instructed to place bags from the recycling bins in the trash compactors, because the recycling bins in the past had substantial amount of non-recyclable materials in them. Also, the use of black bags, instead of being transparent, precluded any recycling from being processed at the sorting facility. After learning about this issue, clear bags were purchased and new instructions created for the custodial staff. The project was supported by management who quickly made changes. This project also highlighted how key communication and collaboration is to community engagement endeavors.

Project #3

The third project worked with the Executive Director of the Office of Climate Action, Sustainability and Resiliency for the City of Denver, Colorado. The cadets updated the City of Denver's Heat Vulnerability map, compared the 2020 data with the 2013 map of heat vulnerability, as well as proposed effective solutions to combat the problem. Extreme heat events are known to negatively affect human health, especially for those most susceptible to heat such as infants and the elderly, and those who do not have the resources to take refuge from it. Identifying where heat vulnerability occurs is necessary to help mitigate the effects of extreme heat events for at-risk communities as determined by socioeconomic, health, and environmental conditions in 2020.

The students downloaded data on age, race, disabilities, diabetes, education, household isolation, linguistic isolation, and socioeconomic status from the U.S. Census Bureau and the Colorado Department of Public Health and Environment. They also conducted an unsupervised classification of Sentinel-2 data with a 10 meter spatial resolution, which they used to calculate the proportion of tree canopy cover and impervious surface cover for each tract in the City of Denver. They then ran a Principal Component Analysis to determine the appropriate number of composite variables that would best represent the dataset. They found four components could explain approximately 80% of the variance in the 2020 dataset. They then conducted a factor analysis to create a heat vulnerability index and mapped changes to heat vulnerability since 2013. They presented their findings to the client but also at the 2021 GEOINT conference where they proposed mitigation strategies to find relief from heat. This project was successful, but unlike the other projects did not have the USAFA Sustainability Manager as the primary client. It was however directly aligned with the USAFA Sustainability Strategic Plan in that one of the core planning areas involved promoting USAFA as a resource for sustainability engagement with local, regional, and national stakeholders.

Project #4

For the fourth and final project, the students worked with the U.S. Fish and Wildlife Service officer on the installation as the client. This project consisted of documenting the extent of riparian and upland habitat restored at eight sites on the installation. The students used ESRI's Field Maps to set up a data collection mechanism and then conducted field work to collect the data. The cadets also standardized, updated, and organized five maps that are part of the Integrated Natural Resource Management Plan as well as digitally updated the conservation zone for the endangered Preble's Meadow Jumping Mouse (Zapus hudsonius preblei). Natural resource management efforts on campus fit squarely in the Natural and Cultural Resources core planning area of the USAFA Sustainability Strategic Plan.

The students next created data visualizations of additional storm-water runoff due to the construction boom in El Paso County. They studied and classified satellite imagery from 1985 and 2020, mapped new impervious surfaces, calculated the yearly runoff associated with precipitation during those years, and then recorded the change in runoff over those two periods. This project bridged multiple jurisdictions as most of the new construction occurred in the City of Colorado Springs, the Town of Monument, as well as the El Paso County, but due to the topography and the hydrology of the area, most of the runoff from those areas accumulates in the eastern boundary of the installation. The added impervious surfaces, causes the runoff to be more voluminous and enters the creek more rapidly causing severe and costly erosion issues; especially considering the riparian area around the creek is critical habitat for the endangered Preble's Meadow Jumping Mouse.

The Natural Resource Manager needed visualizations to help convey to the surrounding municipalities the impact of new construction. From a lessons-learned perspective, the students found it difficult to convey the uncertainties both in the accuracy of the imagery as well as the

storm-water runoff estimates. This project did align with the Natural and Cultural Resources core planning area of the USAFA Sustainability Strategic Plan.

In retrospect, for all projects, at the end of the semester, it would be beneficial to have the students reflect on what they would do differently if they had to redo (or continue) the projects. This could be added as an ungraded exercise on the last day of class in what we refer to as a "hot-wash."

Second Iteration of the Sustainability in Action Course

The second iteration of the course continued community engagement and provided direct input to the USAFA Strategic Sustainability Plan. For example, at the request of Physical Facilities on campus, one project consisted of creating effective visualizations of water, gas, and electricity usage at USAFA. Students explored seasonal and monthly variations in consumption over two years utilizing different approaches to provide an intuitive and dynamic understanding of trends within the data as well as mapping the results. The results enabled the identification of potential targets for reducing consumption of water, gas, and electricity on the installation. This project contributed to the Energy and Water core planning areas of USAFA Sustainability Strategic Plan.

Another project crafted a self-guided virtual tour of our campus' sustainability features for the Sustainability Manager. The final product consisted of two different virtual tours with a map, photos of each feature, cost savings analysis, and a description of what the feature does, as well as a manual providing instructions that can be used to update the tours in the future. The virtual tour of the current sustainability features can be accessed here: https://arcg.is/1b4ina

Planned features include the installation of native grass species and artificial turf to replace heavily watered turf grass, solar parking canopies, electric vehicle charging stations, dedicated bike lanes, a main dormitory's eco-friendly renovations, and a visitor center mobility hub. Current features include the fieldhouse geothermal mechanical system, solar array farm, non-potable irrigation, LED lights, recycling center, heat plant nitrogen blanket, automatic light sensors, and LEED certified buildings. This endeavor served to advance the Education and Outreach core area of the USAFA Sustainability Strategic Plan as the tours are freely available on the internet. Planned features tours are available at: https://arcg.is/0r48C80.

The last project in the second iteration of the course consisted of developing educational materials to help recycling efforts at USAFA. The client for this project was the USAFA Sustainability Manager. The main deliverables included both a static and interactive map of the locations of recycling bins throughout campus, educational posters for distribution throughout the installation, an article for the Civil Engineering newsletter and the creation of a "USAFA Recycles" website which provided links to both maps, the educational posters created for the project, a list of what is recyclable and some information to dispel recycling myths. The overarching goal of this project was to make the recycling process easy and understandable for all at USAFA but also in the local community, since our recycling center is also used by

individuals in the community. This project served to advance the Education and Outreach as well as Waste core planning area of the USAFA Sustainability Strategic Plan.

While each project may seem disparate, they all provided direct input to USAFA's Sustainability Strategic Plan. After just two semesters of projects/collaborations we witnessed increased sustainability awareness with our students, at the institution-level, and within the region. The knowledge gained through these partnerships and collaborations go beyond the "Sustainability in Practice" course itself. We felt the students saw direct impact of their projects on the on-going development of USAFA's Sustainability Strategic Plan, and this was first step in a life-long educational journey associated with applying elements of sustainability at places of work, at other military installations, and beyond.

Select Lessons Learned

As expected with any new course offering, there were many lessons learned that would be helpful to educators that may consider our approach. For example, we strongly suggest allowing students to select their projects. In the first iteration of the class, the four projects were established and directed by the instructor; but students were placed in their first or second choices using a questionnaire asking them to rank the projects in terms of interest and expertise they felt they could contribute. In the second iteration of the course, the Sustainability Managers and other potential clients across the institution proposed a list of 24 potential projects. Students voted for the eight projects which they felt would be most interested in learning more about. Those projects were offered in detail, and students then completed the questionnaire asking them to rank their preferred projects and briefly explain their choice. We suggest adding a new dimension to project selection where students can propose their own project as long as it contributes purposefully to the institution's Sustainability Strategic Plan or equivalent.

Our type of course can make students uncomfortable, especially if they prefer specific direction. It is crucial to be upfront with students that a service-learning, community engagement, project-based course may be extremely different from other courses. For example, the instructor serves more as a manager, resource, and cheerleader. Also, instructors must be comfortable letting students struggle through issues as they arise and sometimes make decisions with which the instructor might not agree. We recommend allowing students to "fail gracefully" as it will serve as a learning experience for the students. We also recommend only accepting projects in which the instructor has reasonable expertise, or at least has access to someone for methodological or technological assistance as needed.

Another common issue that arises in groups is with social-loafing. This issue is mitigated if each student in the group has specific responsibilities and a clear sets of sub-tasks throughout the semester. Also determining a designated team leader that holds everyone accountable for active participation may be useful, as is keeping a weekly log filled by each individual on their accomplishments and roadblocks. In our course, incorporating peer reviews after each major milestones allowed students to provide feedback on their classmates' performance, which in-turn assisted the instructor in identifying problematic team dynamics.

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Finally, we suggest only entertaining "clients" that are genuinely interested in using the students input if warranted. This is why we felt the connection between the USAFA Sustainably Manager and the USAFA Sustainability Strategic Plan was so critical to the success of the course and is what we are advocating in this paper. At the same time, it may mean that not all aspects of sustainability are attacked at the same time (e.g. compare Table 1 to Figure 2), but over time all core planning areas should be addressed especially as sustainability champions from across the institution emerge and we build on our existing successes and garner more support.

Suggested Future Research and Considerations

For courses similar to our "Sustainability in Practice" offering, we recommend developing performance measurement rubrics or metrics for determining success. For example, we hope to compare USAFA with other USAF and United States Space Force installations. This would need to be the basis of a more comprehensive research project in the future.

We also believe it would be beneficial to develop a vertically integrated multi-year service-learning opportunity for students interested in sustainability. This course would be similar to the "Sustainability in Practice" course we describe in that students would work on real-world project aligned with direct impact to their institution or community; but would be repeatable as many times as a student desires, or the projects could span many years and be commandeered by a new cohort of students in subsequent semesters. Such an approach would allow for larger more comprehensive projects, serve to effectively expand experiential STEM learning opportunities, encourage interdisciplinary interactions, and provide students with leadership opportunities. It could also serve as a new vehicle for seeking donations and sponsorships from external funding sources and partners and engaging others beyond the institution.

Conclusions

We hope that the service-learning community engaged approach to sustainability education described here proves to be a valuable pedagogy that can help students connect the lessons they are learning in the classrooms to the real-world applications they will soon encounter in the workplace. While our efforts are nascent, and we consider this a preliminary effort requiring further investigation to establish the validity of our observations, we feel they are worthy of sharing with other IHEs. We hope other instructors can use our ideas and projects to help address and frame sustainability education at their institution and inspire further research.

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