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Article

Educating the Future of Sustainability

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Abstract: The future of global environmental sustainability is contingent upon educating the next generation of environmental stewards. Critical elements of training such an interdisciplinary workforce include mentoring and experiential learning in the areas of science, communication, and leadership. To keep pace with the ever changing and increasingly complex issues of global environmental sustainability, environmental educators must encourage and support the participation and training of a diverse body of students in the environmental sciences. The Rocky Mountain Sustainability and Science Network (RMSSN) is a partnership of over two dozen universities, federal agencies and other organizations designed to help train the next diverse generation of interdisciplinary leaders who are prepared to address issues related to global climate change, environmental sustainability, and the management of public lands and resources using the Rocky Mountains as a laboratory and classroom. Herein, we present the RMSSN as a model for engaging students in the environmental sciences with an emphasis on understanding key elements of sustainability. Our model is based on a foundation of: (1) diversity; (2) tiered mentoring in cohorts; (3) engaging lectures coupled with field experiences on public lands; (4) long term networking; and (5) environmental internships.

Keywords: environmental sustainability; education; diversity; interdisciplinary

1. Introduction

Each year, the Rocky Mountain Sustainability and Science Summer Academy (Summer Academy) supports interdisciplinary, place-based learning experiences in the form of environmental internships for 25–35 undergraduate students [1]. Prior to these experiences, participants attend the cohort-based, Summer Academy during which they obtain: (1) training in biological field protocols and data analysis; (2) introduction to climate literacy; (3) training on communication in the sciences; (4) introduction to global leadership in the sciences; (5) case studies and problem-based learning related to environmental sustainability; (6) introduction to the interdisciplinary nature of collaboration in the environmental sciences; (7) introduction to the study and preservation of cultural resources on public lands; and (8) introduction to careers related to environmental sustainability, climate change, and preservation of cultural resources. In the Summer Academy Model, this material is presented through a series of lectures and short courses coupled with field experiences. Examples of these couplings are provided in Table 1. A more detailed description of the Summer Academy Model can be found in the 2011 Proceedings of the George Wright Society [2] and a recent publication by Davis *et al*. [3].

Table 1. Examples of summer academy lectures/short courses coupled with field experiences.

Climate Science (1 field lecture; 1 field discussion)	(1) Day hike to Teton Glacier System (2) National Phenology Network Field Exercise
General Ecology/Species Identification (daily short trips)	Bird and wildlife watching around the Jackson Valley using species identification guides and taxonomic keys
Environmental Science (field lecture)	Field: Greater Yellowstone-Teton representative ecosystems
Organizational and Leadership Science (workshop)	Meyers-Briggs Type Indicator Assessment and relation to STEM leadership roles; KGI–Team Assessment
Environmental Communications and Public Policy (discussion and workshop)	Communications Exercise with Madden (former CO State Climate Change Advisor and CO State House Majority Leader) and Trujillo (Communications Director for Senator Udall)
Cultural Anthropology (2 field trips)	(1) Field: Several native cultural sites including one active archaeological excavation; (2) National Museum of Wildlife Art
Watershed Management and chemistry (1 field lecture; 1 field trip)	Field trip to Jackson Lake and Gros Ventre Hot Springs
Geology (1 field lecture; 1 field trip)	Field: Gros Ventre Landslide and Lower Slide Lake
Microbiological Ecosystems (1 field lecture; 1 field exercise; 1 laboratory exercise)	(1) Field sampling exercise at Kelly Warm Springs; (2) Laboratory Culture Exercise using field samples from Kelly Warm Springs.
Sustainable Energy (1 lecture; 2 field experiences)	Visit proposed sites for Jackson Wind Farm and Jackson Hydroelectric

The Summer Academy Model uses a cohort design to engage students during and beyond the initial academy experience. Specifically, the academy uses five teams, each led by a graduate student mentor and one peer mentor (an alumnus from a previous academy) and comprised of four to five

undergraduate participants. All participants and mentors are recruited through the Rocky Mountain Sustainability and Science Network (RMSSN) partners (Table 2). To help train the next diverse generation of interdisciplinary leaders who are prepared to address issues related to global climate change, environmental sustainability, and the management of public lands, the academy places special emphasis on the recruitment of underrepresented minorities. To date, over 75% of Summer Academy participants have been from backgrounds which are traditionally underrepresented in the sciences. The diversity of the graduate mentors is a critical element for encouraging underrepresented participants to pursue the potential of their own graduate education. Each graduate student works with an undergraduate peer mentor and both are charged with the direct mentoring/oversight of one team of undergraduates within the academy. Recent research in undergraduate, cohort-based education suggests that cohorts of five participants or less result in more meaningful and productive mentor-mentee connections, longer lasting networking among peers, and fewer gaps in intervention and retention initiatives [3]. Evaluations of the academy outcomes and a corresponding network analysis both demonstrate the importance of the alumni and graduate students as core network nodes for the undergraduates.

Table 2. Rocky Mountain Sustainability and Science Network (RMSSN) Partner Institutions, Agencies, and Organizations.

Academic Institutions	
Autonomous University of the Yucatan	Colorado State University
George Washington University	Institute of American Indian Arts
Metropolitan State College of Denver	University of Colorado, Boulder
Michigan Technological University	University of Colorado, Denver
Texas A&M University	University of Nairobi
Salish Kootenai Tribal College	University of Wisconsin, Whitewater
University of Montana	University of Wollongong
University of Wyoming	University of Northern Colorado
Utah State University	University of New Haven
Agency Partners	
Bureau of Land Management	National Park Service
United States Geological Survey	Rocky Mountains Cooperative Ecosystems Studies Unit
Organizational Partners	
American Museum of Natural History	Association for Advancement of Sustainability in Higher Education
National Phenology Network	Student Conservation Association
Wyoming Conservation Association	

The Summer Academy also includes groups of professional mentors (for example, USGS regional directors, NPS superintendents, *etc*.) who introduce and discuss topics relevant to the goals of the academy and follow-up with participants according to their disciplines for a period of at least 12 months following the academy. Past STEM professionals have included Colorado Governor's Deputy Chief of Staff and Advisor on Climate Change, US Senator Udall's Advisor on Climate Change, US Senator Udall's Communications Director, Deputy Director of the US Geological Survey, Chief Representative of the US Cartographic Commission to the Pan American Institute of Geography and History,

scientists from the Cooperative Institute for Research in Environmental Sciences, Vice President of the Student Conservation Association, scientists from the Bureau of Land Management and US Forest Service, biologists from the US Fish and Wildlife Service, District Rangers from the US Forest Service, and scientists, engineers, and chemists from the renewable and sustainable energy workforce.

The Summer Academy uses public lands as a laboratory of learning for students. Why do we use public lands? Land resource managers and scientists regularly collaborate on issues related to environmental stewardship, sustainability, and preservation of cultural resources. To properly prepare the next generation of environmental stewards, we train students on the complexity and interdisciplinary nature of public lands management. In doing so, we bridge disciplines and applications so students learn to work in complex ecosystems while also appreciating the science driving such complexity. Public lands are particularly fitting for experiential learning in the ecological sciences as these outdoor laboratories highlight the large scale effects of human impacts driving global ecological change and can be used as a means to promote scientific literacy [1]. An additional benefit of public lands as classrooms is the reintroduction of the outdoors to young adults through positive learning experiences and rekindling cultural connections for many minority groups with limited exposure to natural resources [3–5]. In this way, the Summer Academy trains the next, diverse generation of resource managers who are prepared to develop and implement models of sustainability for public lands which are more resilient to human pressures and climate change.

Over the course of three years, the Summer Academies have been held either at the Shortgrass Steppe Longterm Ecological Research Station adjacent to the Pawnee National Grasslands in eastern Colorado or at the Murie Center situated in Grand Teton National Park near the Moose Visitor Center in Moose, Wyoming. Students who complete the academy along with the associated environmental internship are awarded a Certificate in Global Leadership and Environmental Sustainability from the Rocky Mountain Sustainability and Science Network. We have conducted pre- and post-assessments of student participants to measure their ability to define basic concepts in sustainability and their confidence in assisting managers of public lands and resources with issues related to environmental sustainability. Using a self-efficacy instrument for assessment, we have found that participants of the Summer Academy consistently improve on all measures. Here we present our findings and offer the Summer Academy as a model for educating students on concepts related to sustainability.

2. Methods

We administered a self-efficacy instrument before and after the Summer Academy experience to measure students' abilities to define basic concepts in sustainability along with their confidence in assisting public lands and resource managers on issues related to environmental sustainability. Within the pedagogical framework of cohort-based experiential learning, analysis of self-efficacy provides a reliable metric for assessment of educational outcomes [6–11]. Self-efficacy measures the beliefs related to an individual's understanding and ability to perform specific tasks [12,13]. For our assessment, students were asked to read a series of statements and rank the strength of their belief in their abilities to attain the indicated outcomes. Strengths were rated on a scale of 1–10 with (1) indicating a very weak belief in a student's abilities and (10) indicating a very strong belief in a student's abilities.

Pre- and Post-self-efficacy instruments were administered to students prior to the Summer Academy (Pre-) and following the completion of their internships (Post-). A total of 71 students completed the surveys over a period of three Summer Academies. For each pre- and post-self-efficacy assessment, the same five statements were evaluated:

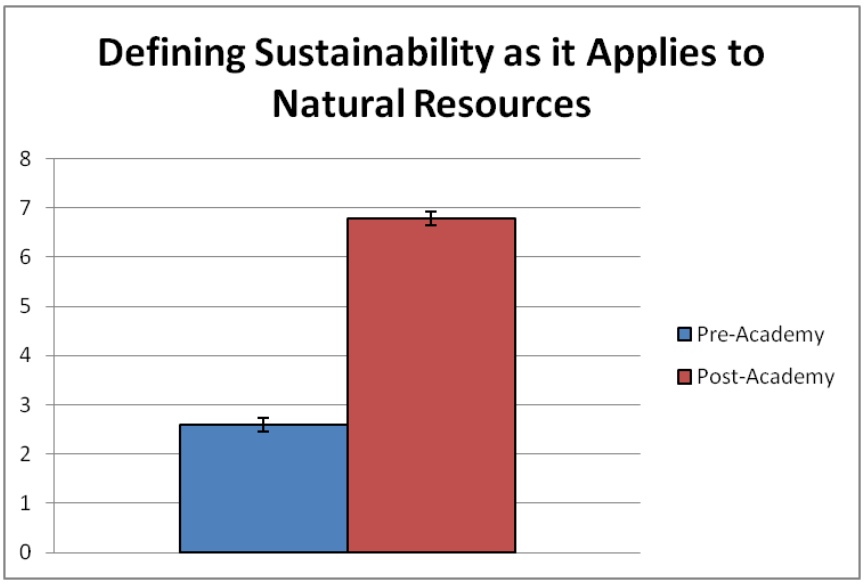
(1) I can clearly define sustainability as it applies to natural resources.
(2) I can clearly define sustainability as it applies to public lands.
(3) I can clearly define sustainability as it applies to climate change.
(4) I can effectively assist public lands managers on issues related to sustainability.
(5) I can effectively assist natural resource managers on issues related to sustainability.

3. Results and Discussion

3.1. I Can Clearly Define Sustainability as It Applies to Natural Resources

A total of 71 participants responded to both the pre- and post-self-efficacy question related to their ability to define sustainability as it applies to natural resources. The results are graphically represented in Figure 1. On a scale of 1–10, the average pre-assessment ranking was 2.605634 and the average post-assessment ranking was 6.788732. The standard deviation and standard error for the pre-assessment ranking were 1.164706 and 0.138225, respectively. The standard deviation and standard error for the post-assessment ranking were 1.217908 and 0.144539, respectively. Therefore, we concluded that students' ability to define sustainability as it applies to natural resources was significantly enhanced as a result of the Summer Academy Experience.

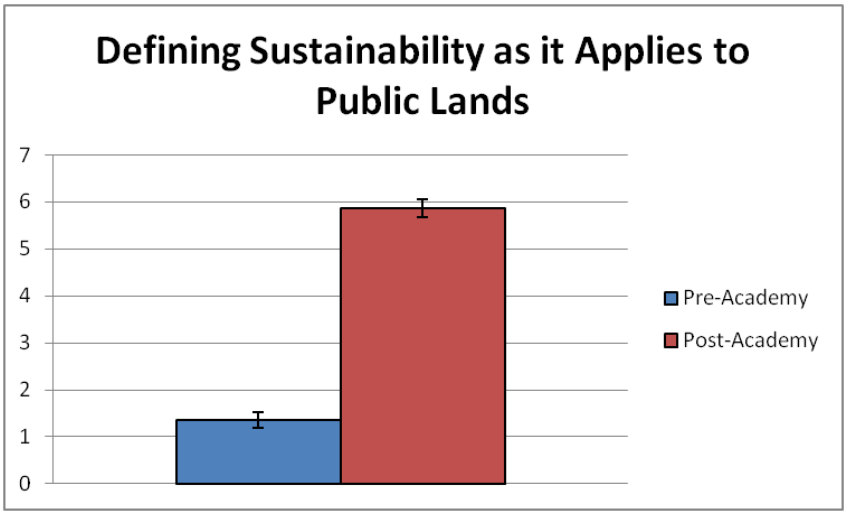
Figure 1. Average ranking of students' ability to define sustainability as it applies to natural resources before (blue) and after (red) the Summer Academy.



3.2. I Can Clearly Define Sustainability as It Applies to Public Lands

A total of 71 participants responded to both the pre- and post-self-efficacy question related to their ability to define sustainability as it applies to public lands. The results are graphically represented in Figure 2. On a scale of 1–10, the average pre-assessment ranking was 1.359155 and the average post-assessment ranking was 5.859155. The standard deviation and standard error for the pre-assessment ranking were 0.633489 and 0.161302, respectively. The standard deviation and standard error for the post-assessment ranking were 1.579293 and 0.187428, respectively. Therefore, we concluded that students' ability to define sustainability as it applies to public lands was significantly enhanced as a result of the Summer Academy Experience.

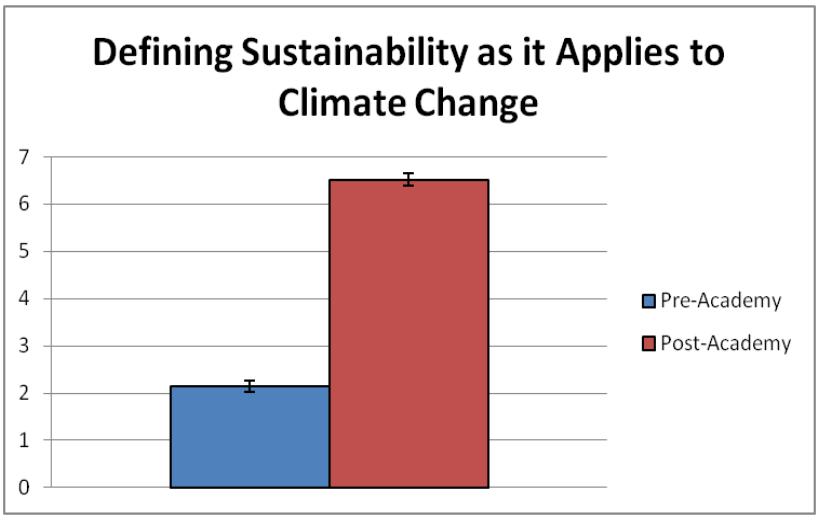
Figure 2. Average ranking of students' ability to define sustainability as it applies to public lands before (blue) and after (red) the Summer Academy.



3.3. I Can Clearly Define Sustainability as It Applies to Climate Change

A total of 71 participants responded to both the pre- and post-self-efficacy question related to their ability to define sustainability as it applies to climate change. The results are graphically represented in Figure 3. On a scale of 1–10, the average pre-assessment ranking was 2.140845 and the average post-assessment ranking was 6.521127. The standard deviation and standard error for the pre-assessment ranking were 1.011146 and 0.12, respectively. The standard deviation and standard error for the post-assessment ranking were 1.132118 and 0.134357, respectively. Therefore, we concluded that students' ability to define sustainability as it applies to climate change was significantly enhanced as a result of the Summer Academy Experience.

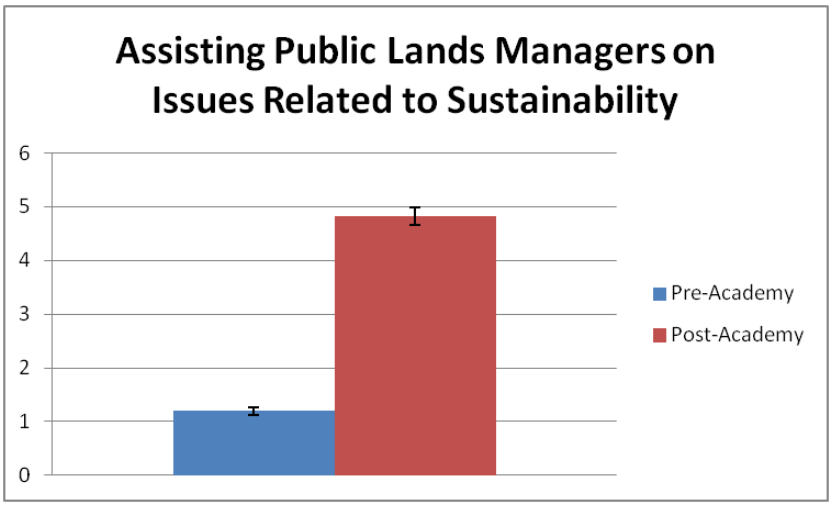
Figure 3. Average ranking of students' ability to define sustainability as it applies to climate change before (blue) and after (red) the Summer Academy.



3.4. I Can Effectively Assist Public Lands Managers on Issues Related to Sustainability

A total of 71 participants responded to both the pre- and post-self-efficacy question related to their ability to assist public lands managers on issues related to sustainability. The results are graphically represented in Figure 4. On a scale of 1–10, the average pre-assessment ranking was 1.197183 and the average post-assessment ranking was 4.830986. The standard deviation and standard error for the pre-assessment ranking were 0.550836 and 0.065372, respectively. The standard deviation and standard error for the post-assessment ranking were 1.362623 and 0.161713, respectively. Therefore, we concluded that students' ability to effectively assist public lands managers on issues related to sustainability was significantly enhanced as a result of the Summer Academy Experience.

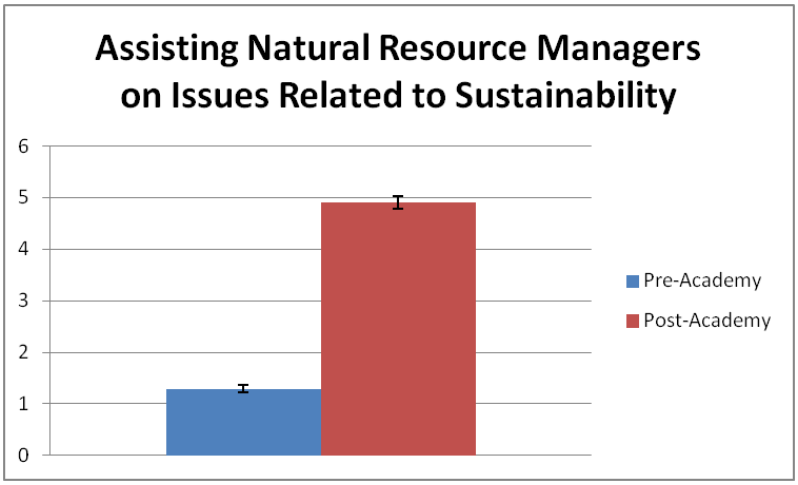
Figure 4. Average ranking of students' ability to assist public lands managers on issues related to sustainability before (blue) and after (red) the Summer Academy.



3.5. I Can Effectively Assist Natural Resource Managers on Issues Related to Sustainability

A total of 71 participants responded to both the pre- and post-self-efficacy question related to their ability to assist natural resource managers on issues related to sustainability. The results are graphically represented in Figure 5. On a scale of 1–10, the average pre-assessment ranking was 1.295775 and the average post-assessment ranking was 4.901408. The standard deviation and standard error for the pre-assessment ranking were 0.641301 and 0.076108, respectively. The standard deviation and standard error for the post-assessment ranking were 1.057692 and 0.125524, respectively. Therefore, we concluded that students' ability to effectively assist natural resource managers on issues related to sustainability was significantly enhanced as a result of the Summer Academy Experience.

Figure 5. Average ranking of students' ability to assist natural resource managers on issues related to sustainability before (blue) and after (red) the Summer Academy.



4. Conclusions

The future of environmental sustainability is dependent upon the education of an interdisciplinary workforce with broad skills related to environmental stewardship. At the basis of that education must be a core understanding of sustainability and the development of confidence in one's ability to use acquired skills to contribute to sustainability management issues. Over the past three years, the Summer Academy of the Rocky Mountain Sustainability and Science Network has implemented a model of cohort-based experiential learning to do just that. The results of our ongoing self-efficacy assessments indicate that our model has been highly effective in helping the next generation of practitioners and leaders of environmental sustainability to: (1) define sustainability as it applies to natural resources; (2) define sustainability as it applies to public lands; (3) define sustainability as it applies to climate change; (4) develop confidence in participants' ability to assist natural resource managers with issues related to sustainability; and (5) develop confidence in participants' ability to assist public lands managers with issues related to sustainability. To maximize the utility and broader impacts of the scientific training provided at the Summer Academy, participants have also been cross-trained in communication and organizational leadership. In this way, the Summer Academy is achieving the overarching goal of the Rocky Mountain Sustainability and Science Network, "to help

develop the next diverse generation of leaders who are prepared to address future issues in environmental sustainability

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Author Contributions

Bowser, Gretzel, Davis and Brown designed the research plan and performed the research. Gretzel and Brown analyzed the data. Bowser and Brown wrote the paper.

Conflicts of Interest

The authors declare no conflict of interest.

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