Transforming US higher education to support sustainability science for a resilient future: the influence of institutional administrative organization

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Abstract Interdisciplinary environmental and sustainability (IES) academic programs have an important and distinctive role in education for sustainability: preparing sustainability-oriented problem solvers who work at the science–policy, science–management, and policy–management interfaces. IES programs are rapidly expanding at college and universities in the USA and exhibit a variety of forms, including interdisciplinary degree programs housed within a traditional department; programs that span departments, a college, multiple colleges, or the entire university; programs that reside in their own IES departments, schools, or colleges; and degree programs located within IES institutes and centers. A very few institutions are addressing IES education in a holistic manner by developing dedicated campuses for sustainability education or reorganizing their entire campus structure to support sustainability science education and research. This paper presents how Unity College, a small environmental college, reorganized its administrative structure, curriculum and pedagogy around a sustainability science framework. It also illustrates the influence that various forms of IES programs have on sustainability education in the USA as revealed by national studies conducted by the Center for Environmental Education Research of the National Council for Science and the Environment.

Keywords Sustainability education · Higher education · Interdisciplinary environmental education · Higher education administration

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1 Introduction

How higher education should reorganize administratively to support education and research for sustainability is a topic of extensive debate in the USA. Many reports have stressed the need for academic reorganization and new institutional structures to facilitate interdisciplinary/transdisciplinary research and education (e.g., Pfirman and the AC-ERE 2003, 2009; National Academy of Sciences 2014). Discussion centers on the conceptual and physical separation of disciplines around which US university structures have been traditionally organized.

Research universities and colleges in the USA are typically structured in a hierarchical system based on administrative units termed departments which are organized into larger administrative units called colleges. Other terms used for administrative units are schools, divisions, programs, and institutes/centers. Departments serve as the administrative homes for specific disciplines such as biological sciences, chemistry, and economics. Departments are led by department chairs/heads who report to the dean of their college. Colleges serve as the administrative homes for groups of similar disciplinary departments; for example, a college of engineering may include departments in civil and environmental engineering, electrical and computer engineering, chemical engineering, mechanical and aerospace engineering, etc. Colleges are led by deans who report to the institution’s chief academic officer/provost. Schools may be more similar to a department, such as a School of Marine Science and Policy within a College of Earth, Ocean and Environment, or they may be more similar to a college, such as a School of Business. The term school is often used instead of college for professional academic programs such as architecture, business, law, etc. Leaders of schools within colleges report to the college dean while leaders of schools similar to colleges report to the chief academic officer.

Division is another term used in different ways—a division can represent a group of faculty in a smaller college, such as a Division of Natural Sciences, or it may be used to define a larger unit, such as a Division of Agriculture that includes a College of Agriculture and Natural Resources and the university’s related community advisory services unit, its Agricultural Extension Service. The term division is most often used in smaller schools; these are similar to departments with division chairs that report to a college dean. Program is the term used for degree programs with curricula that span multiple departments. Many interdisciplinary environmental and sustainability (IES) degree programs are administered through programs. Program curricula may span a few departments in a college, most or all the departments within a college, departments in multiple colleges, or departments across the entire college/university. The leaders of programs are program directors who most often report to one or more college deans. Institute and center are terms used for administrative units created to facilitate interdisciplinary/transdisciplinary research across units and in many cases to support applied and sponsored research with external organizations. Some also administer IES degree programs. Institute directors most often report to top administrators—the office of the president/chancellor, the chief research officer, or the chief academic officer. Centers are most often located within a college with directors that report to the college dean.

These administrative structures are replicated in institutions’ physical structures, budgeting procedures, curriculum design, course development and delivery, faculty standing (tenure) and promotion processes, and student advising and eligibility requirements for degrees. Departments and colleges often have their own distinctive spaces and buildings separated from other colleges and departments across the campus. Departments are also cognitively separated by different knowledge, epistemologies, and accepted research
methods. Standards used to determine professional standing within colleges and universities and within professional societies are based on disciplinary expertise and reinforce boundaries between the disciplines. Most research and education activities occur within departments with limited interaction with other units across campus. Colleges and departments predominate in budgeting allocations.

We and many others argue that traditional institutional organization impedes transdisciplinary sustainability education and research (e.g., Ferrer-Balas et al. 2008; Miller et al. 2011; Vaughter et al. 2013; Desha and Hargroves 2014). Recognition that the complex global challenges related to sustainability require solutions that draw upon the knowledge, methods, and skills across many academic and professional disciplines has led to an increasing focus on ways to break down the administrative, physical, cognitive, and professional standing barriers to inter- and transdisciplinary collaborative education and research.

To illustrate how institutional structure influences education and research for sustainability, we first present a case study of how Unity College, a small liberal arts college, transformed its organization and core curriculum to support a new institutional focus on a sustainability science framework for all students, regardless of their area of study. The second author is the president of Unity College. Second, we review the research on IES education and research programs conducted by the Center for Environmental Education Research (CEER) of the National Council for Science and the Environment (NCSE) to illustrate the wide diversity of IES degree program structures in US colleges and universities, and what national surveys reveal about how these differences in structure are related to differences in curricula and leaders’ views on their programs’ success as an interdisciplinary unit. The first author is the director of the CEER.

2 The Unity College sustainability science framework

Unity College is a small, privately funded, liberal arts undergraduate institution (<600 students) located in the state of Maine. It was established in 1965 as an environmental college focused on preparing students for environmental citizenship and careers. Throughout its history, Unity College built its programming around students’ experiential engagement in the study of natural resources and conservation. Working with stakeholders and agencies is a key part of the student experience. Over the last decade, Unity College faculty and students have participated in research on hemlock forest ecosystems using a transdisciplinary, sustainability science, problem solving model. The success of this work inspired the faculty and the Board of Trustees to vote unanimously (in 2012) to develop a transdisciplinary, sustainability science framework for the entire undergraduate curriculum at Unity College.

2.1 Rationale

The implementation of a sustainability science framework requires a different approach to teaching, learning, and research. Environmental and sustainability are vibrant and growing fields, although both still struggle to fulfill their promise of linking knowledge to action and achieving true transformative integration that contributes to feasible and effective solutions development (Clark et al. 2011a; Schoolman et al. 2012; Wiek et al. 2011, 2012; Leal Filho 2014). A key constraint is the need for new modes of education and research: “linking knowledge to action for sustainability … requires a very different type of research and education … research that
generates knowledge that matters to people’s decisions and engages in areas where power dominates knowledge; and education that enables students to be visionary, creative and rigorous in developing solutions and that leaves the protected space of the classroom to confront the dynamics and the contradictions of the real world” (Wiek et al. 2012: 1).

Developing a transdisciplinary sustainability science framework for Unity proceeded from the understanding that sustainability science requires problem solving via integration of the natural and physical sciences with the social sciences, built upon a foundation in the humanities (Kates 2011; Jahn et al. 2012). Students need to develop understanding not just of the natural environment, but of the human dynamics that interface with environmental processes in complex, coupled human-natural systems.

Consistent with the need for a new approach to education is the emphasis within sustainability science on transdisciplinary pedagogy (Kajikawa 2008). In practice, interdisciplinary pedagogy at US higher education institutions often consists of assembling a patchwork of disciplinary courses with different paradigms, perspectives, and languages that may or may not be relevant to the specific problems students will be called upon to solve. In contrast, Unity conceives transdisciplinary pedagogy as predicated on the concept that disciplines are integrated through the process of solving problems (Tamura and Uegaki 2012). It teaches the student or practitioner how to get all of the information they need to successfully address issues. A review of the key competencies for sustainability literature conducted by Weik et al. (2011) revealed that sustainability competencies are process based and derived from the teaching and learning dynamic in which problems are considered. Systems thinking, strategic thinking and management, understanding of normative context, and anticipation of future contingencies are essential to the framework. These are integrated through what Weik et al. (2011) refer to as interpersonal competence, which requires the practitioner to work with stakeholders who have shared ownership of the problem and may hold contrasting perspectives. Development of such social science skills is in stark contrast with the limited pedagogy in environmental science (Evans 2012) in which such process-based, social science thinking typically receives only superficial consideration (Clark et al. 2011a, b; Tamura and Uegaki 2012).

The liberal arts, when properly configured, are important for the successful development of sustainability science education programming. The role of the humanities and social sciences as developed in a liberal arts undergraduate curriculum is especially important because these areas provide the prosocial basis for effective engagement with environmental problems (Proctor et al. 2013). Specifically, the liberal arts curriculum has been shown to be effective in cultivating prosocial sustainability outcomes (Pascarella et al. 2005). Moreover, the liberal arts provide fundamental fluency in key skills, including written, verbal, and media literacy. Sustainability science is especially dependent on the integration of learning that is the hallmark of the liberal arts. Outcomes that have been identified as resulting from a liberal arts education include lifelong learning, intercultural effectiveness, post-conventional moral reasoning, and reflective judgment (Seifert et al. 2008). These are consistent with the key competencies identified by Weik et al. (2011) as necessary for effective practice of sustainability science.

2.2 Transforming institutional structure and pedagogy

The Unity College vision of transdisciplinary sustainability science is designed to enable students to become brokers of knowledge, while the faculty will function largely as curators of knowledge. This is possible in large part because of our current era’s essentially unlimited access to information. Information literacy is a skill required of any educated
person, and it is accordingly central to the transdisciplinary process. Students must learn how to identify valid information and manage it in a problem solving context whether we are to truly avail ourselves of the power of universal access to information.

Three factors are crucial to the success of sustainability science as a framework for programming: (1) faculty across the institution must embrace a transdisciplinary, problem-focused pedagogy, (2) students must become fluent at accessing, evaluating, and applying relevant information, and (3) the humanities and social science must be seen as foundational.

Recognizing the intrinsic limitations of interdisciplinary pedagogy and institutional structures that reinforce disciplinary separation rather than integration, the administration and faculty at Unity College undertook radical steps to create new organizational structures to support a new holistic, integrated, transdisciplinary undergraduate pedagogy. Beginning in early 2012, Unity began integrating sustainability into its general education requirements and degree offerings. The framework was first implemented in the general education requirements for all students. This core curriculum—the Environmental Citizen Curriculum—provides a science-based liberal arts foundation. Transdisciplinary pedagogy has been implemented within the Environmental Citizen Curriculum and included as part of courses in a student’s chosen area of study. Central to the core is problem-focused, experiential engagement of the students with real-world problems based on the local and regional community. The Environmental Citizen Curriculum grounds each of the degree programs in a broad liberal arts base. Information literacy is enhanced through emphasis on external resources including exposing students to the peer reviewed literature in relevant disciplines. The framework is now being extended to the upper division courses for degree programs.

Instead of departments, degrees at Unity College are offered through five Centers for Academic Excellence, each representing an area of focus and administering related majors. This innovative structure helps faculty collaborate and share knowledge and resources and allows students to connect with resources across the college. Each center offers degrees focused on specific aspects of action-oriented sustainability challenges. The five centers are the Center for Biodiversity (degrees in Biology and Marine Biology), the Center for Environmental Arts and Humanities (degrees in Art and Environment and Environmental Writing and Media Studies), the Center for Experiential and Environmental Education (degrees in Adventure-based Environmental Education, Adventure Therapy, Captive Wildlife Care and Education, and Secondary Education), the Center for Natural Resource Management and Protection (degrees in Conservation Law Enforcement, Parks and Forest Resources, Wildlife Biology, and Wildlife and Fisheries Management), and the Center for Sustainability and Global Change (degrees in Earth and Environmental Science, Environmental Policy, Law and Society, Sustainable Agriculture, and Sustainable Energy Management).

The center directors and the provost at Unity College are responsible for providing the context and resources to support the development of the sustainability science framework. It is important to note, however, that it is the delivery and the institutional administrative structure that is being modified, not the degree titles. Indeed, most of the implementation of transdisciplinarity occurs at the level of individual faculty in their respective courses. In this respect, the transdisciplinary approach at Unity College represents an efficient use of relatively few resources (i.e., faculty and courses).

The goals of the Environmental Citizen Curriculum in conjunction with a student’s chosen major are: (1) to ground each degree program in a broad liberal arts base, (2) to integrate the humanities and social sciences into scientific disciplines that address specific
environmental and sustainability problems, (3) to engage students in the fundamental questions at the center of sustainability science, focusing on the dynamic intersections of nature and society, (4) to provide students with the communication, critical-thinking, and information skills that support a career as an environmentally literate professional, and (5) to prepare student for the central task of moving knowledge into action through direct participation in this process. Achievement of these goals occurs within three primary spheres: the individual, the community, and the environment. Each sphere includes explicit learning outcomes that are assessed annually.

3 Interdisciplinary environmental and sustainability education in the USA

The National Council for Science and the Environment (NCSE) is a nonprofit organization dedicated to improve the scientific basis for environmental decision making (http://ncseonline.org). Located in Washington, DC, the NCSE specializes in programs that foster collaboration between the diverse institutions and individuals creating and using environmental knowledge, including research, education, environmental, and business organizations as well as governmental bodies at all levels. It hosts an annual conference and global forum on science, policy and the environment that attracts over a thousand scientists, policy makers, government and industry officials, students and faculty to address a current issue—the theme for the 15th annual conference to be held in January 2015 is energy and climate change (http://www.energyandclimatechange.org). The NCSE also serves as the secretariat for three professional organizations for environmental and sustainability academic leaders: the Council of Environmental Deans and Directors (CEDD), the Council of Energy Research and Education Leaders (CEREL), and the Community College Affiliate Program (CCAP). The CEER developed from research initiated in 2003 by CEDD to learn more about the structure and curricula of IES academic and research programs at US colleges and universities. Since 2003, the CEER has conducted national studies of IES education and research programs in the USA and produced reports describing the findings with context provided by reviews of relevant literature and individual program profiles (the reports may be viewed at http://ncseonline.org/ceer-reports).

One of the defining characteristics of US IES programs is their diversity, both in the types of degree and research programs that exist, and in their administrative location/structures within their home institutions. From their historical roots in natural resources management programs to the first programs named environmental studies established in the late 1960s and contemporary environmental and sustainability degree programs, US IES academic and research programs reflect the evolving global environmental movement. Sherburne Abbot, previously an official in the Office of Science and Technology Policy in the Obama administration, identified five waves of the environmental movement that have influenced IES higher education programs and careers (referenced in Ginsburg et al. 2004: 5–9): (1) the preservation movement (1850–1890), concerned with the preservation of wild lands; (2) the management movement (1890–1950), concerned with the prudent, long-term use of natural resources; (3) the ecological movement (1950–1970), marked by increasing understanding of the deleterious effects of human activities on ecosystems and human health; (4) the regulatory movement (1970–1990), distinguished by the establishment of a suite of federal environmental regulations; and (5) the sustainability movement (1990–present), catalyzed by the publication in 1987 of the United Nations World Commission on Environment and Development report, *Our Common Future*.  

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Each of five waves has produced laws, regulations, technical and scientific approaches, and professions and institutions appropriate to the mission and goals of the times. Each wave is built upon the foundations of those that preceded it and the new goals of the present. IES academic programs have evolved along with these waves. Sustainability degree programs emerged in 2006 and now make up the fourth largest group of IES degree programs (Vincent et al. 2012).

Recognition of the importance and urgency of sustainability-oriented problem solving for the health, security, and prosperity of the nation and the world has led to rapidly expanding demand for IES education and research in the USA. The number of IES degree programs has risen from about 500 in 1990 to about 2,000 today (Vincent et al. 2012), and there are approximately 1,200 IES institutes and centers comprising approximately 8 % of all research institutes and centers in the USA, including many that administer academic programs (Vincent et al. 2014). In addition, many other disciplines and professional fields have adopted formal sustainability specializations (Vincent et al. 2013a).

For the purposes of CEER research, IES academic programs are defined as baccalaureate and graduate degree programs that focus on the coupled human-natural systems using a broad approach. These include programs named environmental science, environmental studies, sustainability, environmental policy, environmental management, natural resources, and similar degrees such as coastal science and policy, water resources, etc. Degrees with a primary focus in a traditional discipline or professional field such as conservation biology, environmental economics, or sustainable agriculture are not included, nor are degrees with a more narrow focus such as forestry or fisheries management. IES institutes and centers are similarly defined to include those that focus on environmental or sustainability issues.

The largest proportion of IES degree program names, 40 %, includes the term environmental science or sciences (Fig. 1). Another 25 % includes the term environmental studies. Program names that include natural resource(s) comprise 11 %. The growth in sustainability programs brings this group to 8 %, tied with the proportion that includes policy in their names.

IES degrees are offered in a variety of administrative locations within US higher education institutions, including IES degree programs housed within a traditional disciplinary department, school or division; IES departments, schools, and colleges; IES centers and institutes; IES programs that span multiple departments, one or more colleges, or an entire institution; and IES degree programs operated by a consortium of campuses or institutions. The administrative homes for the majority of IES degrees are interdisciplinary IES academic units or programs. About a third (32 %) are located in their own IES academic unit—a department, school, division, college, center, or institute. Another 43 % are offered through IES programs that span multiple units. The remaining 25 % are located in traditional disciplinary academic departments, schools, or divisions.

CEER research has revealed that the location of IES degree programs is related to the views of the program leaders (the department chairs/heads, the school/college deans, and the program/center/institute directors) on ideal curricula for the degrees they offer (which closely mirror actual curricula) and their views on the factors important for program success (for which program location is a key factor). These relationships indicate that location has important influences on IES curricula and, therefore, on the delivery of transdisciplinary, transformative sustainability education as envisioned by the sustainability education community.
3.1 Sources of the data reviewed

NCSE initiated its extensive research program with a research project that sought to understand the nature and number of IES academic leaders’ perspectives on ideal curriculum design for baccalaureate and graduate degree programs (Vincent and Focht 2009). One of the most important findings from this study is a consensus on the identity of the IES field: It is focused on the interfaces and interactions of coupled human-nature systems with the goal of preparing students to be sustainability-oriented problem solvers. Key learning outcomes include disciplinary synthesis abilities, systems-thinking cognitive skills, knowledge of the sociopolitical and natural aspects of environmental problems, understanding of the limits of science and technology, and recognition of the importance of acknowledging and reporting uncertainty (Vincent and Focht 2010, 2011). This consensus opinion is very similar to the draft minimum standards (threshold learning outcomes) for tertiary programs in the environmental and sustainability field currently under development by Australian Universities with the support of the Australian Government Office for Learning and Teaching (http://environmentltas.gradschool.edu.au).

In 2008, NCSE conducted a census to identify all baccalaureate and graduate IES degree programs offered by universities and colleges in the USA. The census served to define and characterize the population for ongoing research. The census was followed in 2009 by an extensive national survey of IES program leaders. The three related research tasks together comprised the first comprehensive empirical study that sought to identify the defining characteristics of the IES field and describe the diversity of programs’ administrative and curricular structures at US higher education institutions. The national survey of IES academic program administrators elucidated the characteristics that collectively describe the diversity of programs. The findings are summarized in the 2010 NCSE report *Interdisciplinary Environmental Education on the Nation’s Campuses: Elements of Field Identity and Curriculum Design* (Vincent 2010).
The census of IES programs was updated and extended in 2012. It identified 1,151 academic units/programs offering 1,859 IES baccalaureate and graduate degrees located at 838 colleges and universities. In the 4 years following the 2008 census, the number of higher education institutions offering IES programs increased by 29% and the number of degree programs by 57%. A series of three reports from NCSE illustrate the rapid growth in the IES field overall—especially in sustainability academic programs—and the emergence of new types of interdisciplinary energy programs:

- **Interdisciplinary Environmental and Sustainability Education: Results from the 2012 Census of US Four-Year College and Universities** (Vincent et al. 2012)
- **Sustainability Education: Results from the 2012 Census of US. Four-Year College and Universities** (Vincent et al. 2013a)
- **Broad and Non-traditional Energy Education: Results from the 2012 Census of US. Four-Year College and Universities** (Vincent et al. 2013b)

A survey of the leaders of all IES academic programs was completed in spring 2013. The survey instrument was developed with numerous experts and included questions on degree program attributes and curriculum design, program leadership and faculty, administrative structures and resources, internal and external partnerships, and influences on programs’ success. A series of reports will present the findings from the survey, combined with case studies and relevant literature review. Two reports have been completed (additional reports are in preparation):

- **Interdisciplinary Environmental and Sustainability Education on the Nation’s Campuses 2012: Curriculum Design** (Vincent et al. 2013c)
- **Interdisciplinary Environmental and Sustainability Education on the Nation’s Campuses 2012: Leadership and Administrative Structures** (Vincent et al. 2015)

All 1,151 IES program leaders were asked to participate in the survey. Survey responses were received from 354 IES program leaders (a response rate of 31%), who provided data about their roles as primary administrator, their programs’ structure and resources, and their views on the factors important for program success (262 completed this question). The program leaders also provided data on the characteristics and curriculum of 242 undergraduate and 112 graduate IES degree programs (total 363, 20% of all US IES degree programs). Both samples are representative of IES programs nationally. The statistical frequencies reported have a margin of error of ±5%. The sample sizes for the data used in the statistical analyses are sufficient to measure correlations between attributes with a power of .90 to detect a .20 effect size at \( \alpha = .05 \). Details of the statistical methods used to analyze the survey data are included in each report.

A separate survey of the directors of IES institutes and centers (IESICs) at research universities was completed in summer 2013. This survey included questions on the institutes’ and centers’ mission and goals, administrative structure, personnel, and resources. The census identified a total of 1,121 IESICs at 236 universities. The directors of these IESICs were invited to participate in the survey. Completed survey responses were received from the directors of 340 IESICs for a response rate of 28%. A report of the findings was released in March 2014: **Interdisciplinary Environmental and Sustainability Education and Research: Institutes and Centers at Research Universities** (Vincent et al. 2014). The statistical frequencies for this report also have a margin of error of ±5%, and the sample was representative of the population.
4 IES program location and managing for success

The administrative locations of IES degree programs within their institutions influence their leaders’ abilities to manage the factors that contribute to programs’ success. We did not predefine program “success” in the survey since there is disagreement on what this term means. Individual views of program success will differ based on institutional contexts and constraints. See the 2015 leadership and administrative structures report (Vincent et al. 2015) for the survey questionnaire.

As explained above, ten different administrative/structural configurations exist for IES academic programs in the USA: IES degree programs housed within a traditional disciplinary department, school or division; IES departments, schools, and colleges; IES centers and institutes; IES programs that span multiple departments, one or more colleges, or an entire institution; and IES degree programs operated by a consortium of campuses or institutions. These ten configurations may be consolidated into four primary groups based on their capacities as discussed below: (1) degree programs administered by an IES unit at the primary level of the university—an IES college, school, institute, or center, (2) programs administered through an IES department (or equivalent school or division within a college), (3) degree programs administered through a traditional department (or equivalent school or division within a college), and (4) degree programs administered by programs that reside outside of other units.

These four groups are used because most faculties in the USA are administratively located in departments (or equivalent units) where their professional standing and promotion is determined. Most courses/classes are also developed and controlled at the department level. IES departments have IES faculty and develop IES courses for their degree curricula. IES colleges (and similar units) often have core faculty appointed within the unit and develop their own core courses but also draw upon faculty and classes taught across the institution. In contrast, most IES degree programs within disciplinary departments and programs outside of departments rely on faculty and courses supplied by traditional disciplinary departments either voluntarily or through contractual agreements. IES degree programs within traditional disciplinary departments use courses primarily developed for their disciplinary degree students. IES degree programs create curricula based primarily on courses from various disciplinary departments taught by faculty whose jobs are dependent upon their department’s disciplinary standards.

In terms of managing for success, a location within a traditional department was revealed by the NCSE survey to be the least desirable for IES degree programs while a location within an autonomous IES academic unit (department, school, college, center, or institute) is most desirable. Administrative agency (autonomy and capacity to direct resources) is the key element that allows interdisciplinary IES programs to fully attain their educational, research, and service missions. Administrative independence and the capacity to obtain and direct resources are intimately tied to the three other fundamentals of effective program design: adopting an overall vision/goal aligned with workforce and societal needs, implementing truly interdisciplinary curricula, and involving students in real-world interdisciplinary knowledge-production research and decision-making policy and management processes. In addition, administrative agency (i.e., tenure track faculty lines or equivalent) can go a long way toward ameliorating the professional standing and promotion challenges often cited as problematic for interdisciplinary educators and scholars (e.g., Pfirman 2011).

The NCSE survey asked program leaders to gauge the importance of various factors on the success of IES programs in general and the level of their satisfaction with how their own program addressed or utilized each factor in its own success (Table 1). A four point
Table 1 Effect of program administrative location on satisfaction

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<tr>
<th>Influencing factor</th>
<th>Proportion highly satisfied</th>
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<td>IES department n = 65 (%)</td>
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<td>Highly satisfied (%)</td>
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<tr>
<td>Curriculum factors (moderate to high importance)</td>
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<td>Incorporating real-world problems</td>
<td>71</td>
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<td>Incorporating research experiences</td>
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<td>Developing courses</td>
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<tr>
<td>Designing academic programs</td>
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<td>Incorporating internship experiences</td>
<td>48</td>
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<td>Incorporating applied experiences</td>
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<td>Sequencing courses</td>
<td>32</td>
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<tr>
<td>Curriculum approval process</td>
<td>31</td>
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<tr>
<td>Institutional factors (moderate to high importance)</td>
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<td>Unit/program leadership</td>
<td>25</td>
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<td>Student interest/support</td>
<td>65</td>
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<td>Faculty participation</td>
<td>69</td>
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<td>Institutional support (resources)</td>
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<tr>
<td>Institutional leadership</td>
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<td>Unit/program location within institution</td>
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<td>Campus sustainability efforts</td>
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<td>Competition with other units</td>
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<tr>
<td>Support grant management support</td>
<td>31</td>
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<tr>
<td>Graduate employment factors (moderate importance)</td>
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<td>Local/regional employment</td>
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<td>International employment</td>
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<th>Influencing factor</th>
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<td>IES department ( n = 65 ) (%)</td>
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<td>Career services support</td>
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<td><em>External support factors (low importance)</em> (^a)</td>
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<td>Compete for foundation and private funding</td>
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<td>Compete for federal funding</td>
<td>11</td>
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<td>Win public support</td>
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<td>Compete for state and local funding</td>
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<td>Win political support</td>
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<td><em>Partnership factors (low importance)</em></td>
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<td>Foreign higher education partnerships</td>
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\(^a\) For these factors, moderately and highly satisfied rankings are combined since so few programs are highly satisfied with their ability to compete for/win external support.
scale was used: minimal/no importance or satisfaction, low importance or satisfaction, moderate importance or satisfaction, and high importance or satisfaction. Five groups of influencing factors were rated: (1) curriculum factors, (2) institutional factors, (3) graduate employment factors, (4) external support factors, and (5) partnership factors.

The factors in three of the groups—curriculum, institutional factors, and graduate employment factors—were rated of high or moderate mean importance for the success of IES programs (with the exception of international employment opportunities) while the factors in the other two groups—external support and partnership factors—were all rated of mean low importance, although the levels of importance placed on these factors are higher for autonomous IES units. Seven factors were rated as highly important: (1) designing academic programs, (2) developing courses, (3 and 4) incorporating research and real-world problems into courses, (5) program leadership, (6) students’ interest and support, and (7) faculty participation. There are significant differences (using Kruskal–Wallis analysis of variance by ranks test $\alpha = .05$) in levels of satisfaction based on location for twelve factors: (1) institutional leadership support, (2) unit/program administrative location, (3) faculty participation, (4) grant support, (5) ability to compete for federal funding, (6) ability to compete for state/local funding, (7) ability to win political support, (8, 9, 10, and 11) ability to engage in partnerships with other higher education institutions (both domestic and foreign), governmental organizations, and private and non-profit sector organizations, and (12) the ability to incorporate internship experiences into curricula.

Not surprisingly, the levels of satisfaction with various factors that influence program success are often higher for programs within their own IES administrative units. Administrators of IES departments are most satisfied with their ability to design curricula, increase student interest, win public and political support, enhance faculty participation, effectively manage grants, compete for state/local funding, participate in community, NGO, and foreign higher education institution partnerships, and prepare students for local and regional employment.

Other IES units—schools, colleges, centers, and institutes—have the highest satisfaction levels with their location within their institution, institutional leadership support and resources, unit leadership, ability to compete for private funding, ability to participate in partnerships with governmental organizations, and ability to prepare students for national and international employment opportunities. Programs that span units have the highest levels of satisfaction with their curriculum approval process, career service support, and their ability to participate in private sector and other higher education institution partnerships. IES programs in traditional departments have the highest levels of satisfaction in their ability to compete with other units and their ability to participate in campus sustainability efforts.

A separate analysis of this data revealed three views on IES program leadership (Vincent et al. 2015). Because of space constraints, these results are not discussed in detail here but are available in the leadership and administrative structure report. It is mentioned here because the importance placed on the IES program’s location within the institution is one of the key areas of difference between the three views. The three leadership views are distinguished from each other by the number of factors rated of higher importance and the level of importance placed on various factors. Leaders with the Leadership View 3 perspective rank all factors of moderate to high importance, Leadership View 2 leaders view rate 69 % of the factors of moderate to high importance, and Leadership View 1 leaders rate only 59 % of the factors of moderate to high importance.

Key areas of difference include: the importance placed on program location within the institution, the importance placed on alignment with employment opportunities, and the
importance of partnerships of all types. Leadership View 1 places lowest importance on all these factors, Leadership View 3 places the highest importance on these factors, and Leadership View 2 falls in between.

5 IES program location and ideal curricula

Two national surveys, conducted in 2009 and 2013, asked IES program leaders to rate the importance of various knowledge areas and skills in what they view as the “ideal” curriculum for each of the degrees their program offers (as well as the emphasis in the current curriculum). We did not predefine the term “ideal” curriculum since there is disagreement on what this term means. Individual views on “ideal” curricula will differ based on individual degree program goals in the context of their home institution (many institutions offer several types of IES degree programs). See the 2013 curriculum design report (Vincent et al. 2013c) for the survey questionnaire.

The scale for determining the ideal curriculum was minimal/no importance, low importance, moderate importance, and high importance, while participants ranked these factors’ presence in their current curricula on a scale of minimal/no emphasis, low emphasis, moderate emphasis, and high emphasis. The knowledge and skills areas included were vetted by a number of IES education experts from the Council of Environmental Deans and Directors, the American Association for the Advancement of Science, the Association of Environmental Studies and Sciences, the National Association of Environmental Professionals, the Association for the Advancement of Sustainability in Higher Education, and other organizations. The original survey included similar, but fewer, knowledge and skills areas than the more recent survey which included 41 knowledge areas and 38 skills areas.

The ratings data were analyzed using social science statistical techniques to reveal interdisciplinary components of knowledge and integrated skills for IES program curricula and how these components are integrated in ideal curricula (Vincent 2010; Vincent et al. 2013c). The results of the analyses include three broadly defined approaches for ideal undergraduate IES curriculum design and two approaches for ideal IES curriculum design for graduate programs (for details, see the reports cited above). The results were very similar for both surveys, with minor differences due to changes in the number of knowledge and skills areas included. The convergence of these two studies with different samples strengthens the conclusions. The most recent findings are reviewed here.

The three undergraduate approaches to ideal curricula are labeled Natural Systems Emphasis, Social Systems Emphasis, and Sustainability Solutions Emphasis based on the knowledge and skills components each emphasizes. The three approaches represent the views of groups of program administrators that rate the ideal curricular components for their undergraduate degrees in similar ways. Figures 2 and 3 illustrate how the mean importance ratings of the knowledge and skills components differ from the overall mean for all undergraduate IES programs (the mean for all programs = 0, standard deviation = 1) and from each other for each of the three ideal approaches.

Figure 4 illustrates a framework for understanding the relationships between these approaches to undergraduate IES programs (individual degree programs can be plotted on this diagram—see Vincent et al. 2013c for details). The three approaches are not opposed to each other; instead, they overlap so that some undergraduate IES programs are situated on the boundaries of two or three groups.
The three approaches are oriented on two dimensions of skills and knowledge: (1) sustainability solutions emphasizing collaborative engagement, system-thinking and project management skills and sustainability, built environment, social sciences, systems, and humanities knowledge; and (2) natural sciences and traditional laboratory and field research emphasizing informatics, laboratory, and research skills; and physical and life sciences knowledge.

The two graduate approaches are similar to the undergraduate and are similarly labeled *Natural Systems Emphasis* and *Sustainability Solutions Emphasis* based on the knowledge and skills components each emphasizes. For graduate programs, statistical analysis produces only two groups with the more social systems-oriented degree programs falling into the same group as the solutions-oriented degree programs to form a single *Sustainability* approach.
Solutions Emphasis group. This likely reflects differences between undergraduate and graduate programs—graduate programs emphasize professional preparation while undergraduate programs emphasize a liberal arts education with specialization in an area of study. The undergraduate Social Systems Emphasis approach is more targeted to understanding problems than creating solutions. These two approaches also represent the views of groups of program administrators that rate the ideal curricular components for their graduate degrees in similar ways. Figures 5 and 6 illustrate how the mean importance
ratings of the knowledge and skills components differ from the overall mean for all
graduate IES programs (the mean for all programs = 0, standard deviation = 1) and from
each other for each of the two ideal approaches.

Figure 7 illustrates a framework for understanding the relationships between the two
approaches to graduate IES programs (individual degree programs can be plotted on this
diagram—see Vincent et al. 2013c for details). The two models are oriented on a social
dimension function emphasizing social research, project management, and public com-
munications skills and sustainability, governance, and policy knowledge with some pro-
grams situated on the boundaries of the two groups.

The popularity of the three different approaches to ideal undergraduate IES education is
similar: The Sustainability Solutions Emphasis model represents 37% of the
undergraduate degree programs included in the survey, the *Natural Systems Emphasis* 34 %, and the *Social Systems Emphasis* 29 %. For graduate degree programs, the *Sustainability Solutions Emphasis* represents 66 % of the IES degree programs and the *Natural Systems Emphasis* 33 %.

The approaches are derived from program leaders’ preferences for ideal curricula; additional data were collected on actual curricula, or the level of emphasis placed on the knowledge areas and skills. The alignment of current curricula with ideal curricula indicates that the program leaders’ preferences are reflected in current curricula, although most do not achieve their ideal emphasis on all knowledge and skills areas and all have variable emphasis on some knowledge and skills areas depending upon individual students’ plans of study.

Table 2 illustrates the proportions of degree programs aligned with each approach and their administrative locations within their institutions. Most undergraduate IES degree programs are located in their own IES department or equivalent unit (such as a Department of Environmental Science) or a program than spans disciplinary departments (such as an Environmental Studies Program). A small proportion is located in disciplinary departments or equivalent (such as a Department of Biological Sciences). Only a few are located in an IES school, college, institute, or center (such as a School of Sustainability or Institute for the Environment). IES graduate degrees are more evenly distributed among the four location types, but similar to undergraduate programs, most are located in their own IES department or in a program that spans traditional disciplinary departments.

Based on the location of their programs and their level within the university hierarchy, IES program leaders have differing administrative capacity to control and direct resources. It is reasonable to expect that program leaders in these different situations would have different views on the ideal curricula for their IES degree programs, and this is indeed illustrated in Table 2. Undergraduate degree programs located in IES departments are most likely to align with the *Sustainability Solutions Emphasis* approach. Degree programs located in traditional departments (many are natural sciences departments) have a preference for the *Natural Systems Emphasis* approach. Degree programs located in IES colleges or in programs that span units have a more equal distribution among the three approaches, which likely reflect institutional contexts—how and why these programs were created.

Most IES graduate programs align with the *Sustainability Solutions Emphasis* regardless of their administrative location. However, there is a relationship between ideal curricula models and administrative location. IES colleges, schools, institutes, and centers are most likely to administer graduate programs with a *Sustainability Solutions Emphasis* orientation; IES departments are least likely. For IES degree programs located in traditional units, most graduate programs are oriented toward the *Sustainability Solutions Emphasis*, but undergraduate programs are more likely to align with the *Natural Systems Emphasis*. Programs that span disciplinary units also have more graduate programs aligned with the *Sustainability Solutions Emphasis*, but undergraduate programs are relatively evenly split across the three models, with more *Social Systems Emphasis* degrees.

IES departments are more likely to administer undergraduate degrees that align with the *Sustainability Solutions Emphasis* but less likely to have graduate degrees aligned with the *Sustainability Solutions Emphasis*. This apparent dichotomy may possibly be explained by the foci of faculty research programs: Traditional units offer graduate programs in their own disciplines as well as IES graduate programs, thus the IES programs are more likely to be substantially different from their other graduate programs. Many IES departments have evolved from roots in the natural sciences—biology, ecology, and geosciences—and therefore faculty research programs may be more likely to emphasize a natural sciences approach.
Table 2  Administrative locations of IES degree programs by ideal curriculum model

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<th>Undergraduate curriculum approach</th>
<th>Administrative location</th>
<th>Total</th>
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|                                    | IES department  \\
n = 75 (%) | Traditional department  \\
n = 44 (%) | IES school, college, or institute/center  \\
n = 9 (%) | Program that spans units  \\
n = 114 (%) | Undergraduate degrees  \\
n = 242 (%) |
| Sustainability solutions emphasis | 47 | 29 | 22 | 35 | 37 |
| Natural systems emphasis           | 33 | 48 | 56 | 27 | 34 |
| Social systems emphasis            | 20 | 23 | 22 | 38 | 29 |
| Total                              | 100 | | | | |

| Graduate curriculum approach      | IES department  \\
n = 42 (%) | Traditional unit  \\
n = 15 (%) | IES college, school, institute or center  \\
n = 22 (%) | Program outside unit/span units  \\
n = 33 (%) | Graduate degrees  \\
n = 112 (%) |
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<td>Sustainability solutions emphasis</td>
<td>50</td>
<td>67</td>
<td>91</td>
<td>70</td>
<td>66</td>
</tr>
<tr>
<td>Natural systems emphasis</td>
<td>50</td>
<td>33</td>
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<td>Total</td>
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6 Conclusion

The effectiveness and limitations of various IES program structures—those that strive to transcend current structures and those that try to accommodate current traditional disciplinary department-based structures—can provide insight into the relationship of higher education structure and interdisciplinary education and research. The data presented above suggest that the administrative structure of IES programs affects the ability to manage factors that contribute to program success. Administrative structure also appears to affect the ability to design curricula that implicitly address sustainability as a systems challenge, integrating environmental, economic, and social dimensions in collaborative processes that engage stakeholders and link science and decision making.

Because of the ways institutions of higher education in the USA are structured, IES units—departments (and equivalent schools or divisions within a college) and primary level schools, colleges, institutes, and centers—have the advantages of administrative agency (autonomy and capacity to direct resources), which is the key characteristic that allows IES programs to fully attain their educational, research, and service missions. Currently, only about a third of all IES degree-granting programs are located within their own interdisciplinary autonomous IES administrative units (Vincent et al. 2012).

A very few institutions, such as Unity College, are addressing sustainability education in a holistic manner, developing dedicated campuses for sustainability education, or reorganizing their entire campus structure to support sustainability education and research. Another notable example is Arizona State University, one of the largest research universities in the USA, which has undergone and is continuing to undergo radical reorganization to support sustainability education and research across the campus (Blanchet 2008; Capaldi 2009).

Older IES programs (those created before 1990) tend to be housed in their own IES units—departments, schools, or colleges—while younger programs tend to be located in programs that span multiple units or in traditional disciplinary departments (Vincent et al. 2014b). Some older programs expanded from natural resource management emphases, such as the School of Forestry and Environmental Studies at Yale University (est. 1900). Others were established as interdisciplinary environmental schools or departments, including the School of Public and Environment Affairs at the University of Indiana at Bloomington (est. 1972) and the Department of Environmental Science and Studies at Allegheny College (est. 1972).

Although most IES programs established in the last two decades ( ~ 80 %) are programs that span units or degree programs within traditional units, recent years have seen a steady stream of new IES research and education-focused colleges, schools, centers, institutes, and campuses. The proportion of IES degrees administered through these types of IES programs has increased rapidly—from 4 % in 2008 to 10 % in 2012 (Vincent et al. 2012, 2014). These institution-spanning structures can fulfill a number of important institutional goals by supporting an explicitly transdisciplinary IES community, while also drawing upon related strengths across the campus. They can nurture interdisciplinary and transdisciplinary research and projects by providing a stable forum for developing and implementing joint ventures. They can create a visible university organization dedicated to solving pressing sustainability problems—becoming a focal point for external organizations seeking assistance and advice on environmental and sustainability issues and supporting collaborative environmental and sustainability teaching and research with partner institutions and organizations.

These structures also provide the capacity to promote sustainability education programs across the campus, thereby coping with burgeoning student interest in, and employer
demand for, environmental and sustainability education (Bezdek et al. 2008; Carnevale and Cheah 2013; United States Bureau of Labor Statistics 2014). They can offer their own IES majors, as well as general education classes in environmental issues and sustainability for all students; certificates, minors, and dual majors for students in disciplinary and professional programs; and continuing education certificates, courses, and degree options for career professionals.

IES programs are instrumental in their colleges’ and universities’ contributions to solve the challenges of the twenty-first century. They contribute to educating future decision makers, conducting environmental and sustainability research, promoting community outreach and service, engaging with campus sustainability initiatives to develop models of best practice, supporting collaborative research within the university, and leading collective research and project implementation projects with a diversity of external partners.

Institutions of higher education in the US have embraced the imperative of supporting sustainability education and research, but in many cases are not taking the necessary steps to reorganize their administrative structures, allocate resources, and change faculty professional standing processes to facilitate effective sustainability education. As we have illustrated, IES degree programs that are based in disciplinary departments tend to offer IES degree programs with less of an emphasis on sustainability and less focus on integration and solutions creation. IES programs that span disciplinary departments struggle to succeed due to a lack of resources and have severe curriculum constraints due to their reliance on disciplinary departments. IES departments in larger schools are constrained in their ability to collaborate with other departments, especially those located in different colleges. Ideally, higher education institutions in the US will follow the examples of Unity and Arizona State University in holistically transforming their structure to support sustainability education across the entire campus. In situations where this level of change is not yet feasible, we assert that colleges and universities should consider establishing primary level schools, colleges, or institutes to serve as the administrative home for IES education because they are uniquely positioned to support sustainability-focused interdisciplinary and transdisciplinary education and research for IES students and across the institution.

While this paper focuses on the organization of US higher education institutions and their IES programs, the findings have relevance for higher education institutions worldwide by illustrating how administrative organization influences the potential and capacity to support tertiary-level sustainability education and research.

References


