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Interdisciplinary environmental and sustainability education: islands of progress in a sea of dysfunction

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Abstract This essay describes the inequity faced by most interdisciplinary environmental and sustainability (IES) degree programs and the impact of that inequity on student and faculty experiences. Despite the urgent need for IES education and research to solve critical environmental and sustainability challenges, as well as high demand for IES education by students and employers alike, we illustrate and discuss how the majority of IES programs suffer from limited resources or unequal standing relative to the traditional disciplines. Traditional disciplinary departments, which dominate university structures and were created decades before most IES programs, often have a monopolistic grip on hiring, firing, and the tenure-granting process. We argue universities must structurally reform to support IES programs, given that this disciplinary silo problem is so deep-rooted and restrictive. We assert the urgent need for equivalent autonomous status and equivalent resources for IES programs, preferably as schools, colleges, and institutes or centers that have core interdisciplinary faculty and draw upon resources across the university, or for smaller schools as IES departments. We also strongly support initiatives to more effectively support the integration of IES knowledge across all higher education curricula. We conclude with a list of recommendations we believe are necessary to support IES higher education.

Keywords Environmental studies programs · Tenure · Departmental resources · Interdisciplinary programs · University structure · University resources · Sustainability education

The views expressed in this essay by Shirley Vincent are her own and do not represent the views of the Center for Environmental Education Research or the National Council for Science and the Environment.

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Introduction: layers of dysfunction

Within this century, the convergence of key global sustainability challenges will determine the fate of human societies and the functioning of the biosphere. Over the coming decades, climate change will be a significant multiplier of ongoing threats to human well-being including, but not limited to, destructive land use; loss of biodiversity; phosphorus carbon; and nitrogen cycle disruption; disease spread; energy water; and food security; freshwater shortages and pollution; and ocean acidification. New, interdisciplinary system approaches, rather than traditional disciplinary approaches, are crucial for addressing these challenges: "System integration—holistic approaches to integrating various components of coupled human and natural systems across all dimensions—is necessary to address complex interconnections and identify effective solutions to sustainability challenges" (Lin et al. 2015: 963).

In 2003, the then newly established National Science Foundation Advisory Committee for Environmental Research and Education (NSF AC-ERE) issued a 10-year guidance document. The report, *Complex Environmental Systems*: *Synthesis for Earth*, *Life and Society in the 21st Century*, stressed the importance of interdisciplinary environmental education and

research for "local, national and global security, health and prosperity" (Pfirman and the AC-ERE 2003: 1).

Subsequent NSF AC-ERE reports continue to stress the urgent need to "expand our capacity to study the environment as an integrated system that includes the human dimension" and underscore the fact that time is running out to respond effectively to the rapid pace of environmental change (NSF AC-ERE 2009: 6). The 2013 National Academy of Sciences report *Sustainability for the Nation*: *Resource Connection and Governance Linkages* emphasizes that achieving sustainability is a "systems challenge that cannot be addressed by separately optimizing pieces of the system" (NAS 2013: vii).

The increasing recognition of the critical need for societal need-driven education and research exemplified by the emerging field of sustainability science has led to rapidly expanding demand for interdisciplinary environmental and sustainability (IES) education. A majority of students (61 %) consider colleges' commitments to environmental issues, including academic offerings, in their decision on which school they will apply to and attend (Princeton Review 2014). Higher education institutions in the USA have sought to respond to this demand through the development of over 2000 IES degree programs (Vincent et al. 2012, 2014). New majors, minors, certificates, and executive education programs in environmental areas and sustainability are being established at an extraordinary pace, and existing programs are striving to keep up with student demand. The number of IES baccalaureate degrees grew by 57 % between 2008 and 2012, master's degrees by 68 %, and doctoral degrees by 35 %. Enrollments also continue to expand, increasing by 49 % for undergraduate programs and 15 % for master's level programs.

Jobs for IES program graduates are in high demand and are more recession-proof in comparison with other fields. The US Department of Labor predicts a 15 % increase in the number of environmental scientist and specialist positions between 2012 and 2022, higher than the average for all life, physical, and social science occupations (11 %) and higher than the average for all occupations (10 % Bureau of Labor Statistics 2014). A recent study shows that college graduates in environmental fields (natural resources and environmental sciences) have some of the lowest unemployment rates compared with other majors; environmental science graduates have a lower unemployment rate than majors in other physical and life sciences (Carnevale and Cheah 2013).

Given the urgent societal need and the increasing demand for IES education and jobs, an observer might assume that these programs would be generously supported and widely respected by colleges and universities, whose mission statements include the goal of serving society. In reality, there are profound and persistent structural issues that must be addressed if IES programs are to be effective agents for the education and research required to solve critical societal issues.

Anecdotes from the frontlines

We begin with three brief anecdotes from our careers that illustrate the persistent issues facing IES education: dealing with departments in interdisciplinary hires (Roberts), experiencing the consequences of a defunded program (Mulkey), and earning an interdisciplinary environmental science doctorate (Vincent).

Roberts has led environmental programs at three mid-sized public and private universities for over 20 years. In all three universities, these programs were unable to hire their own faculty because disciplinary departments held the exclusive power of hiring to the tenure track. In hiring, assessments to identify acceptable candidates were conducted by traditional departments, thus excluding in the first limiting screen many truly interdisciplinary scholars and those with other key skills and experiences sought by environmental programs. In one situation, a department sought to exclude candidates of interest to environmental studies, and a reminder letter from the Dean was required to rebalance decision making by the jointly staffed search committee. Seven years later, the faculty member was rejected for tenure by department vote due to a lack of publications in core disciplinary journals. Roberts appealed the decision, referencing language in the requested Dean's letter from the original search, and the departmental vote was overturned by the Provost. It should go without saying how unappealing it would be to show up to work in a unit by which one had been rejected. This story was a relative success, however, compared to several interdisciplinary hires who were encouraged or forced out at tenure or interim third-year review by departments who were applying evaluation metrics mostly or even entirely on the basis of narrow disciplinary expectations. The environmental units Roberts led were never able to hire interdisciplinary PhDs or geographers into tenure-track lines—these are arguably the key glue needed to integrate what were essentially multi-disciplinary environmental programs.

The University of Florida embarked on an unusual experiment in the early 1990s to create a College of Natural Resources and Environment (CNRE). Structured as an administrative shell with funding for three staff and graduate student fellowships, the college used faculty volunteers and courses from multiple other colleges to offer undergraduate and graduate interdisciplinary degree programs in the environmental sciences. Although co-equal with other UF colleges in degree-granting and graduate student selection authority, CNRE did not have its own faculty or courses and thus could not develop a research profile nor directly change degree curricula. Initially, the CNRE thrived and the participating faculty were afforded sufficient latitude by their home departments to embrace its programming and advise

its graduate students. In 2004, the Institute of Food and Agricultural Sciences (IFAS) acquired the college and transformed it into the School of Natural Resources and Environment (SNRE), at which point Mulkey became director of research. IFAS is home to only one college, the College of Agriculture and Life Sciences. Although many faculty constituents were alarmed by this structural change, initially the budget increased substantially and plans for hiring faculty with joint appointments in other units were discussed. Budgets in all colleges contracted in the 2008–2009 recession, however, resulting in a striking decrease in funding and the loss of authority to fund graduate students advised by faculty in other colleges, leading to the cessation of participation by out-of-college faculty. The initial structure of CNRE presented only an illusion of autonomy, and its reincarnation as SNRE, combined with economic stress, greatly compromised the intended interdisciplinary reach of this initiative.

Vincent earned a doctorate in environmental science from one of the oldest and largest environmental science graduate programs in the country, the Environmental Science Graduate Program (ESGP) at the Oklahoma State University. The program provides students great flexibility in designing their plans of study but provides virtually no guidance on integrating knowledge and skills into a coherent interdisciplinary degree. Vincent's plan of study included only one required core introductory course offered by the ESGP—a survey of current environmental issues—and courses from six departments: political science, sociology, zoology, geography, statistics, and research evaluation and measurement statistics. Integrating the knowledge and skills learned from these courses into a rational body of environmental knowledge and methodological expertise was essentially left to her as an individual student. ESGP students are administratively and physically housed in the departments of their research advisors, who often stress the primacy of their individual disciplines and have limited experience with interdisciplinary research. The most important deficiencies were the lack of any formal preparation in synthesizing disciplinary perspectives, understanding diverse epistemologies, and using a systems approach to problem solving—three elements that distinguish the interdisciplinary environmental field from other disciplines and professional fields (Vincent and Focht 2009, 2010). In addition, in most departments, ESGP students do not have equal access to the assistantships and support provided to other departmental graduate students. Despite being one of the largest graduate programs at the university, ESGP students work in isolation in their individual departments, many arguably not receiving a truly interdisciplinary education.

These three anecdotes represent common experiences for IES program administrators, faculty, and students. Exceptional, well-supported IES programs do exist; examples include the Nicholas School for the Environment at Duke University, the Bren School of Environmental Science and Management at the University of California, Santa Barbara, the Department of Environmental Studies and Environmental Science at Dickenson College, and the Center for Environmental Policy at Bard College. A few universities and colleges have gone so far as to restructure their entire institutions to support IES programs as well as integrate interdisciplinary, sustainability-oriented problem solving across all curricula, as exemplified by Arizona State University (Capaldi 2009) and Unity College (Vincent and Mulkey 2015), but such models are rare. Notwithstanding these islands of success, profound structural problems beset the majority of IES programs in the USA.

The core problem for most IES programs is a lack of administrative agency (autonomy and resources): the key characteristic that allows academic 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 fundamentals of effective IES program design, in particular: adopting an overall vision/goal aligned with workforce and societal needs, implementing truly interdisciplinary curricula, and involving students in real-world applied interdisciplinary research and decision-making policy and management processes.

Current college and university structures based on disciplinary departments organized into colleges dictate many programmatic elements: physical space, budgeting procedures, curriculum design issues, 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 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 them. Most research and education activities occur within departments with limited interaction with other units across campus. Colleges and departments predominate in budgeting allocations. The monopolies that disciplinary departments often hold on faculty hiring, tenure and promotion, budgeting, and eligibility for degrees constitute major barriers for most IES programs.

We first discuss the extent of the problem and then provide recommendations on how universities and colleges must change their current structures and practices to effectively support IES education and research.

The problem is widespread: data from a nationwide census and survey

Data from a recent national census and survey (2012–2013) of interdisciplinary environmental and sustainability (IES)

programs conducted by the Center for Environmental Education Research (CEER) of the National Council for Science and the Environment (NCSE) illustrate that a lack of functional autonomy and resources is common.

For CEER's purposes, IES academic programs include degree programs with a focus on coupled human-nature systems using a broad, interdisciplinary approach. These programs include those named environmental science(s), environmental studies, natural resources, sustainability, environmental policy, and environmental management. This definition also includes programs focused on specific themes, such as water science and policy, urban and environmental studies, and coastal science and management, as well as emerging new types of programs focused on environmental systems/dynamics, climate and energy, international/global issues, and programs combining environmental science and engineering. CEER studies do not include programs with a primary focus in another discipline or professional field, such as conservation biology, environmental engineering, sustainable agriculture, or natural resources economics, nor do they include degrees with a narrow natural resources focus such as wildlife management, fisheries management, or forestry.

Most US IES programs are either based in traditional disciplinary departments such as biological sciences or geosciences (25 %) or are organized as programs that span traditional disciplinary departments or equivalent units (43 %). Only about a third are located in their own autonomous IES units—an IES department, school, college, institute, or center (Vincent et al. 2012). A CEER survey of a representative sample of 334 IES programs reveals that the programs that span units are relatively equally distributed among those that span a few departments, most or all departments in one college (or equivalent unit), departments in two or more colleges (or equivalent units), or departments across the entire institution (Vincent et al. 2015).

Interestingly, older programs (those created before 1990) are more likely to be stand-alone IES units (departments, schools, and colleges) while younger programs, which make up ~80 % of those established in the last two decades, tend to be located in programs that span multiple units or in traditional departments (Vincent et al. 2015). Many older programs expanded and evolved from their roots (often in natural resources), such as the School of Forestry and Environmental Studies at Yale University (est. 1900), but other programs were established as IES units, such as the School of Public and Environmental Affairs at the University of Indiana at Bloomington (est. 1972) and the Department of Environmental Studies and Sciences at Allegheny College (est. 1972).

Figure 1 illustrates that programs at research universities are more likely to be housed in their own IES units than programs at smaller colleges and universities, but nevertheless, over half of the IES programs at all types of institutions are either housed within or span traditional disciplinary units.

The diminished status of most IES programs—those that span or are located in traditional disciplinary departments—is reflected in relatively reduced or non-existent budgets, lacking space or lab facilities, few or no dedicated faculty appointments, and constraints on the ability of program administrators to manage for success (Vincent et al. 2015; Vincent and Mulkey 2015).

About a fifth of all IES programs report that they have no dedicated budget, and less than half report that their budgets are equivalent to programs with similar numbers of students (Vincent et al. 2015). Those whose budgets are equivalent or higher than similar programs are most often located in their own IES departments, schools, or colleges. Graduate programs in traditional departments are especially impacted; only 22 % report budgets equivalent to the other graduate programs offered by the department. Most IES programs also do not receive grant overhead; instead, overhead is distributed to the home units of participating faculty or is retained by the upper administration.

Faculty appointments are also scarce for most IES programs. Almost half (46 %) of unit-spanning IES programs have no full-time faculty appointed within the program and those that do have one or two who typically serve as the program administrators, who often only have a small part-time appointment (Vincent et al. 2015). These administrators are often expected to maintain teaching and research responsibilities in their tenure home departments in addition to their duties directing their IES programs. Over half of unit-spanning IES programs also do not have any joint appointments, contract faculty (those with primary employment within the university), or adjunct faculty (those with primary employment outside the university). Many do not even have formalized arrangements with affiliated faculty and must rely completely on the goodwill of the volunteer departments and faculty that participate. Faculty housed in departments are pressured to teach and research in that discipline, sharply reducing their IES productivity.

The survey included a question asking program leaders to gauge the general importance of 32 factors on the success of IES programs as well as the level of their satisfaction with how their own program addressed or utilized each factor (Vincent et al. 2015). 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 results of the ratings indicate that a location within a traditional department is least desirable, followed by a location in a unit-spanning program. Administrators of IES units are more satisfied with their ability to effectively manage their programs. Administrators of IES departments are more 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, prepare students for local and regional employment

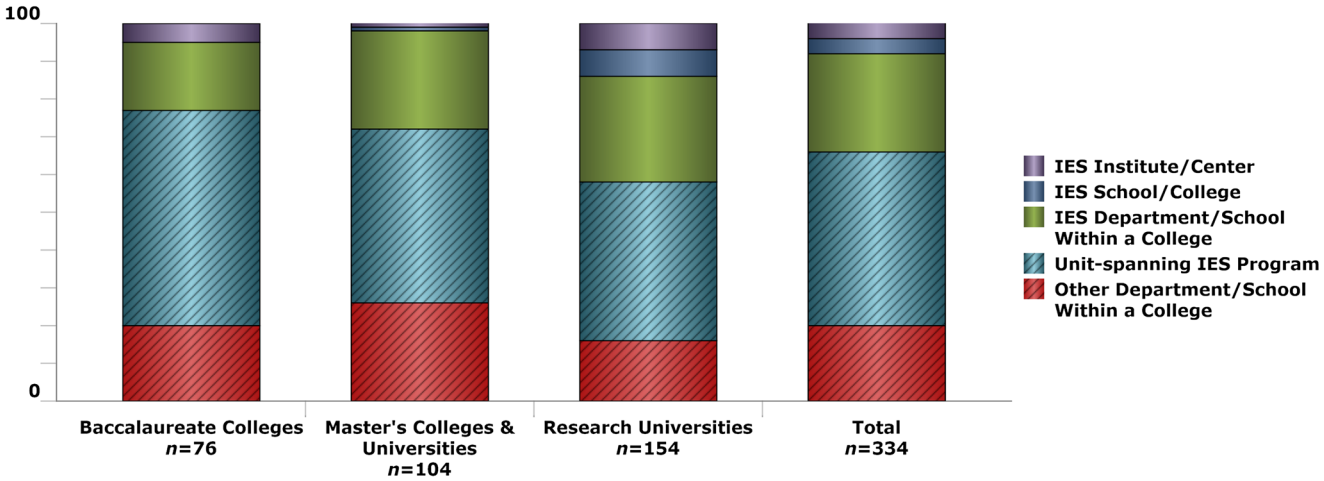

Fig. 1 Location of IES programs within their home institutions by Carnegie classification type

opportunities, and participate in partnerships with their local communities, non-governmental organizations, and foreign higher education institutions. Administrators of IES 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.

Overcoming inertia and restructuring for autonomy

The results described above show that the majority of IES programs (68 %) suffer from limited resources or unequal standing relative to the traditional disciplines at most colleges and universities. Often, faculty participate in these programs with the implicit permission of their home departments but with no formalized agreement, which can ultimately lead to departmental concerns about faculty productivity, promotion, and tenure, a situation that often negatively impacts untenured faculty (Pfirman and Martin 2010). Many higher education institutions have suffered budget pressures as enrollments have stagnated or dropped, and state support has been reduced over the previous couple decades. Marginalized environmental programs often suffer as a result, despite the fact that their programs are in high demand by students and employers.

One advantage often suggested for IES programs without departmental, college, or equivalent status is that since "the walls are low" they can more easily recruit volunteer participating faculty across the institution. However, this arrangement can limit engagement to tenured, often late-career faculty who are willing and able to take on "overload" teaching or committee work and advising in environmental and sustainability programs, which can be problematic.

All programs need to have autonomy to succeed, and without sufficient support from central administration, including real money that is secure, they will fail. Separate small endowments (usually for student "enrichment" efforts) represent an important resource for interdisciplinary centers, but they are sometimes repurposed for core budget needs. Most units on zero-based budgeting models are without the discretionary funding needed to leverage and advance their programs. With pressure to bring in indirect costs, the temptation will often be to give limited support funding only to those who write grants that include institutional support. However, the federal agencies paying these overheads are more likely to fund projects that adhere to the mainstream science model, rather than engaged work that directly addresses environmental problems and experiments with interventions. These types of engaged work require flexible models for faculty contracts because they involve unusual integration of teaching, research, service, and outreach, often in forms unfamiliar to disciplinary faculty. In short, we are not likely to solve the world's problems with one more article or conference paper, the usual outputs of standard research funding.

In order to address the widespread lack of integration of these programs with the mainstream university, we must look at the way budgets are created and how funds are allocated. Administrations have the purview and sufficient authority to reallocate funding to ensure that these programs thrive, but common budget models require the deans of colleges to deliver results and a balanced budget annually. Responsibility or performance-based funding is designed to foster innovation and efficiency within a given unit but does not provide for outside programs that require engagement with the unit (Snyder 2015). Instead, this approach links the allocation of resources to the accomplishment of desired outcomes, which are often defined by metrics unrelated to the effectiveness of interdisciplinary programming. More importantly, responsibility for the survival of interdisciplinary environmental programs is delegated to entities whose primary responsibility is

to ensure the health of a traditional department or college within the university.

Independent of funding issues, rewarding faculty effort is a crucial, unsolved problem (Pfirman 2011). Traditional metrics for retention, promotion, and tenure often emphasize traditional discipline-based research rather than the applied and interdisciplinary research and external engagement that are so critical for the success of environmental interdisciplinary programs. Although the scientific establishment increasingly respects integrative, collaborative research, traditional departmental committees continue to count beans in a manner that focuses on productivity within traditional disciplinary venues at the expense of interdisciplinary collaboration. Difficulties of measuring quality for evaluation to determine promotion and tenure must be addressed (NSF AC-ERE 2009). In particular, different standards must be applied, e.g., for multi-authored papers in newer interdisciplinary journals. Real-world complex social-environmental problems need more sophisticated interdisciplinary or integrative transdisciplinary approaches (Kajikawa 2008). There is a crucial need for a new model for evaluating quality, impact, and innovation: a more global set of indicators. In these respects, we can learn from fields like geography and public health, which are intrinsically interdisciplinary at most institutions.

Ultimately, university leadership must agree that interdisciplinary environmental and sustainability programs are a very high priority and act to ensure their adequate funding and engagement with the traditional structure of the university. Some form of performance-based funding has been fully implemented or is under development in the vast majority of state public institutions. Although the goals of this approach are laudable, the metrics by which outcomes are assessed must include those appropriate for these essential interdisciplinary programs. Student enrollments need to be credited to their concentrations and not merely to departments where faculty instructors have their appointments. Interdisciplinary grants should assign indirect returns to IES. Obviously, allocation of resources to interdisciplinary programs away from the traditional units of the university is politically challenging in an era of contracting budgets.

Recommendations for IES programs include

1. Fully integrated IES (interdisciplinary environmental and sustainability) programs should have authority over staffing and resources and recognized status as an autonomous unit within the university.
2. IES units should have their own core faculty lines in sufficient numbers and ranks to ensure effectiveness to meet their mission. Continuity of faculty is necessary for program stability, so tenure track positions are required.
3. University budgets should explicitly allocate base funding for these programs in sufficient amounts to ensure continuity. Development support needs to be provided for expanding new initiatives.
4. IES leadership and staff should be adequate to ensure innovation and development of the program.
5. Affiliated or jointly appointed faculty that participate in IES programs should have formalized tenure and promotion criteria that recognizes the importance and value of their interdisciplinary research, IES teaching, service, and outreach activities. There should be opportunities for all faculty to devote some proportion of their efforts to interdisciplinary programs.
6. Clear guidelines for retention, tenure, and promotion should be developed for all faculty that participate in IES programs.

We must also recognize that such critically needed structural administrative changes will not fully address the need for integration of understanding from the disciplines. Perception of the weakness of environmental studies, faculty, and students seems widespread in colleges and universities, but much of this is based on ignorance of or misunderstanding by disciplinary faculty of the goals and practice in applied and cross-disciplinary work. This is not vocational work; it is a highly sophisticated management of human and ecological systems and of material and energy flows through extremely complex systems. Students need skills that have been drawn from the full array of disciplines necessary to address environmental and sustainability problems. Moreover, students must acquire the ability to integrate disciplinary information and be trained in the emerging new interdisciplinary areas of expertise. Thus, these programs must provide a research and learning framework that breaks down the control over knowledge and empowers the student with the ability to apply such knowledge in a holistic, problem-solving process. Such pedagogy has been termed "transdisciplinary." Information literacy is foundational to the transdisciplinary approach, which is for the first time in history supported by almost universal access to information via the Internet (Kajikawa 2008). Such integration requires that faculty act as curators, librarians, and guides while students develop the ability to critically assess sources and content.

The problems identified in this article are not going away with time; if anything, we have seen hardening of many institutional barriers over our three decades of working in this area and a lowering of expectations of what is possible, especially as budgets have contracted. The evidence reported here shows that higher education has largely failed in its ethical obligation to prepare students to face the sustainability challenges of the coming decades. Institutionally, the most common types of IES units are unable to deliver training adequate to the challenge. The present crisis in higher education offers an opportunity to realign institutional priorities with the overarching

mission to maintain and renew civilization. Autonomy, we have argued, is the key, whether that takes the form of a school of sustainability, an institute for the environment, or a department of environmental studies and sciences. Universities and colleges that embrace sustainability and empower it with the necessary creativity and dedication allow it to breathe new life into the academy and allow students and faculty to more effectively confront the existential issue of our own survival.

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