



Valuing, Learning: Revising a Sustainability Curriculum for First-Year Students

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“We cannot think first and act afterwards. From the moment of birth we are immersed in action and can only fitfully guide it by taking thought” –Alfred North Whitehead¹

Introduction

In engineering education, a common problem is that sustainability is often taught simplistically or as an afterthought when it is taught at all.² In PowerPoint presentations at engineering schools across the country, there is often one slide with the United Nations Brundtland Commission’s 1987 definition of sustainable development as meeting the needs of the present without compromising the rights of future generations, perhaps followed by another slide of the three pillars of the triple bottom line: economy, environment, and society (or worse, “people, planet, and profit”). Professional codes of ethics and ABET requirements are sometimes applied, with sustainability introduced as a design constraint.³ In our experience, these professional requirements are often treated only in senior design projects, and then only as items on a checklist. Optional minor and certificate programs may exist for those engineering students who are interested, but even here crucial tensions often go unexplored between definitions of sustainability (between weak and strong sustainability^{4, 5}, between “technological sustainability” and “ecological sustainability”⁶, between “eco-efficiency” and “eco-effectiveness”⁷, or between sustainability and sustainable development^{8, 9, 10, 11}) and even between areas of the triple bottom line.³ Missing, too, are important ways of historicizing sustainability as a concept and careful work to integrate domains and disciplines—from engineering, ecology, environmental science, and business to politics, psychology, economics, cultural studies, rhetoric, and communication.¹² In theory, sustainability seems to us to offer the perfect example of engineers’ need for humanists, social scientists, and natural scientists to help with *formulating* and *framing* problems, and for scientists’ and humanists’ need for engineers to sort through the complex products and processes that solve, create, and solve problems again.^{2, 12}

Several years ago, our first thought to redress this problem at Rose-Hulman Institute of Technology was to educate the faculty, to create supply to prepare for demand. Following the model of sustainability across the curriculum which has worked at schools such as Northern Arizona University and Emory University and has been emulated in North America and beyond,^{13, 14, 15} we sought federal and local grants that would pay interested faculty to learn more about sustainability, sustainable engineering, and sustainable design and then incorporate learning modules into one or more of their courses. While this model has worked at other engineering schools,^{16, 17, 18, 19} a number of cultural and institutional barriers beyond the scope of this paper have prevented a similar approach from working at ours. We do, however, have faculty-training programs in entrepreneurship and innovation, values that are clearly more important to our institutional culture than sustainability is, regardless of how these concepts are defined.^{20, 21, 22}

For decades, the pedagogical literature on higher education has been nearly unanimous on the role that the first year plays in students’ learning, at every taxonomic level. The freshman year is

the time to create expectations and habits as well as “interdisciplinary cognitive skills and course-specific knowledge.”²⁴ Likewise, the scholarship on sustainability in colleges and universities clearly shows that education for sustainability must be pervasive and foundational, not super-added only in junior and senior courses. Unlike the prevailing curricular model in engineering education—in which introductory courses teach basic science and mathematics, prior to the intense disciplinary specialization and professionalism of upper-level courses—the scholarship on sustainability education^{25, 26, 27, 28} points to the need for “learning for sustainable development [to be] embedded in the whole curriculum, not as a separate subject.”²⁹ Authentic, transformative impact is only possible when the concerns of sustainability transcend the periphery of a curriculum to pervade student skill development.

The HERE (Home for Environmentally Responsible Engineering) program, a first-year living-learning community at Rose-Hulman Institute of Technology, was designed to introduce students from multiple disciplines to sustainable engineering. In addition to residential and co-curricular components, the program was built around special sections of standard required courses. Students in the program enroll together first in a freshman writing course, then a humanities and natural sciences course on the global contexts of sustainability, and finally Introduction to Design.

In the four years since our problem began, the problems we have encountered—some expected, some unexpected—seem to us to result most often from a disconnection between our expectations and what the students expect, or what the students are capable of, as well as from their cognitive dissonance about what they think sustainability and engineering actually are. Some of our students’ frustrations are productive, we believe, an important part of growth and transformation, while other frustrations are less so, and even counter-productive. The same could be said of our own frustrations. After intense workouts, by analogy, it can be hard to tell which are the useful pains of exertion, and which the pains of injury. What we need, and what this paper addresses, is a productive way to think through these pains.

What *Should* Students Learn about Sustainability?

Our first step in assessing our first-year students and our living-learning program itself is to identify what we want them to be learning. Because we began our program with existing courses, we began with inherited course objectives, which had to be adjusted. We are still adjusting these. In all teaching, learning outcomes are needed that are not just cognitive but affective, behavioral, attitudinal, and skill-oriented; teachers have to be able to articulate what we think students should know, what we want them to be able to do, and, if not *what* or *how* they should feel, at least we want them to be conscious of the roles their values and emotions play in their thoughts and actions.^{30, 31} As a guide for learning outcomes, Bloom’s taxonomy in the cognitive domain is best known, but the affective dimension is probably even more important for programs that actively seek to integrate living and learning.^{25, 32, 33}

We operate with the assumption that education is more than what Paolo Freire calls the “banking concept,” in which “knowledge is a gift bestowed by those who consider themselves knowledgeable upon those whom they consider to know nothing”³⁴:

- a) the teacher teaches and the students are taught;

- b) the teacher knows everything and the students know nothing;
- c) the teacher thinks and the students are thought about;
- d) the teacher talks and the students listen—meekly;
- e) the teacher disciplines and the students are disciplined;
- f) the teacher chooses and enforces his choice, and the students comply;
- g) the teacher acts and the students have the illusion of acting through the action of the teacher;
- h) the teacher chooses the program content, and the students (who were not consulted) adapt to it;
- i) the teacher confuses the authority of knowledge with his own professional authority, which he sets in opposition to the freedom of the students;
- j) the teacher is the Subject of the learning process, while the pupils are mere objects.³⁴

The constructivist notion of the “guide on the side,” rather than the “sage on the stage,” is one way to put this.³⁵ We prefer Henry Giroux’s conception of emancipatory authority, the problematizing of the hidden curricula of schooling, education for citizenship, and other concepts from Deweyan progressivism and critical pedagogy.^{36, 37, 38} It’s not just what our students know, but what and where and for whom they do what they do with what they value and know, and their commitment to what needs to be done for those whose needs precede and outweigh our own. We also prefer transformative approaches like “critical literacies”³⁹ to a bodies-of-knowledge⁴⁰ or even competencies approach,⁴¹ which more easily reduce learning to knowledge acquisition. The depth and breadth of the engagement we hope for from our students and ourselves makes coming up with any taxonomy or list of outcomes feel inherently reductive. And yet *not* identifying our intended outcomes makes it impossible to assess and evaluate ourselves, blinding our attempts to improve.

This need to identify learning outcomes is especially true for learning about sustainability.^{42, 43, 44,}
⁴⁵ As a contested concept, an informed value system, a vision of a possible future, and as a challenge to business-as-usual, sustainability is complexity itself, over-determined. Even defining it requires interdisciplinarity, and attempting to practice—to live it—in academia requires the integration, or at least the involvement, of all parts of the college campus, a dynamic interaction of research, operations, curriculum, and the lived experience of individuals and communities.^{46,47,48} And yet, again, failing to attempt to define for our students what we want them to learn about sustainability in all its complexity will only continue our students’ unnecessary frustrations.

Because it has taken us a few years to get our program in place, to organize previously disparate material across disciplines into a cohesive and fully interdisciplinary sequence, we are just now in a position to redefine our learning outcomes for the HERE Program. Our most recent list of learning outcomes (Figure 1) is informed by the learning outcomes of the ACPA (American College Personnel Association) (Figure 2) and by the revised established learning objectives of the courses we teach.

Our revised list puts ethics, actions and values and emotions in the top three positions. Engaged learning is a primary goal of any critical pedagogy, especially in education for sustainability, and especially in a living-learning community. Thus, for each outcome, we want our students—not

just our students, but ourselves—to be both subjects and objects in our shared learning.^{49, 50} Importantly, each of these first three outcomes requires the integration of cognitive and affective domains: members of our community must not just define abstractly but situate and apply their ethics. We do not seek abstracted values, but lived, thought-out values. Many of our other learning outcomes (4, 5, 6, 8, & 9) define learning not just academically, not just vocationally, but personally, aiming again to integrate life and work. In short, we see the aim of a living-learning community not just as letting students in one residence hall take classes together, but as a fully integrative approach to applied, transformative, purposive knowledge and growth.^{51, 52} Because professionalization is also an important goal in engineering education, our list culminates with several goals that build from affective, ethical, and cognitive foundations to the more specific abilities we expect of graduating engineering students.

Each student and program instructor will be able to

1. recognize in context, discuss, and demonstrate attitudes, behaviors and personal reflection about their rights and responsibilities to themselves, others, society, and the natural world
2. recognize in context, discuss, and demonstrate attitudes, behaviors and personal reflection about their habits and growth, as well as others', and the implications of these
3. recognize in context, discuss, and demonstrate attitudes, behaviors and personal reflection about their values and feelings, as well as others', and the implications of these
4. define sustainability in multiple ways and locate these definitions in historical, political, professional, and personal contexts
5. define, analyze, and apply to their personal and professional lives basic concepts from ecology and environmental science
6. recognize, locate in context, analyze, and evaluate cultural attitudes and narratives about the human relationship with the built and natural world
7. comprehend, analyze and explain the significance of basic politics of sustainability
8. recognize, analyze, evaluate, synthesize, and apply to their personal and professional principles for sustainable living
9. define, analyze, and apply to their personal and professional lives basic concepts of environmental economics
10. define, analyze, apply, and evaluate basic sustainability organizational concepts, including policies, practices, and values
11. define, apply, analyze, and evaluate principles and tools of sustainable design
12. define, apply, analyze, and evaluate basic sustainability metrics

Figure 1: Learning Outcomes of the HERE Program

Each student will

1. be able to define sustainability.
2. be able to explain how sustainability relates to their lives and their values, and how their actions impact issues of sustainability.
3. be able to utilize their knowledge of sustainability to change their daily habits and consumer mentality.
4. be able to explain how systems are interrelated.
5. learn change agent skills.
6. learn how to apply concepts of sustainability to their campus and community by engaging in the challenges of solutions of sustainability on their campus.
7. learn how to apply concepts of sustainability globally by engaging in the challenges and the solutions of sustainability in a world context.⁴⁴

Figure 2: Learning Outcomes of the ACPA⁴⁴

But What *Can* Our Students Learn about Sustainability?

More specifically, can first-year engineering students actually learn about sustainability in the ways we imagine? Our outcomes are ambitious. Too ambitious, and our students have tended to shut down. The first year of college comes with many limiting—and many favorable—factors. Most of our students are just out of high school, with the cognitive and sociological conditions that come with being eighteen years old. As students who have chosen to pursue an engineering, they are generally experienced and skilled with “well-posed” problems in advanced high school mathematics and science, but generally have little experience or comfort with advanced college courses in mathematics and science (thermodynamics, for example, materials analysis, environmental chemistry, renewable energy), and the concepts, processes, and even openness to ambiguity that can accompany more advanced learning.⁵³ Many students who go to engineering school do so for primarily vocational and financial reasons, and thus have little patience for ventures that do not have clear occupational or fiscal payoff, as they (or their parents) perceive it. This, of course, all too often includes the liberal arts. On the other hand, first-year students are just beginning to form professional identities, so successfully integrating sustainability into their sense of themselves as engineers is potentially more impactful than if sustainability remained only part of senior design.² Because our school, like many, has a residence requirement for first-year students, co-curricular learning seems more possible and more likely to integrate life and work.

Models of development constitute one important way to think about how we might keep our learning outcomes appropriate for first-year college students, though we are wary of the common mistake of misreading taxonomies such as Bloom’s, which categorize and necessarily compartmentalize domains of knowledge, as scales of sequential development in cognition (such as Jean Piaget’s and neo-Piagetian theorists) or in ethics (Kohlberg, Gilligan) or in values (Fowler). Especially from the standpoint of learning about sustainability, it is a mistake to believe that students can or will proceed stepwise from recognition to comprehension to analysis to synthesis. Students learn best about sustainability by project-based learning, collaborative

learning, by reflection, by immersing themselves in interdisciplinary design experiences that are not stripped from context, but are part of the context of students' lives. These experiences can, and must, be scaffolded so that students can manage the challenges of learning. But they can, and must, still be immersive experiences that expose students to the challenges of poorly posed problems with multivariate solutions. Instead of beginning by asking students to memorize abstracted definitions of sustainability, for example, we prefer to begin with a problem we ask students to solve with us—should our handouts for this class be printed on paper or distributed electronically? Why? We can then reflect on the competing definitions of sustainability that emerge as we try to solve this problem—do we want a principle of environmental friendliness that we would want everyone in the world to follow? do we optimize our solution for the social and pedagogical values of being able to write on the page before, during, and after class, plugged or unplugged? How could we quantify, scale, and professionalize this problem? What are your personal preferences? Why? What would make you change them? Definitions of sustainability that emerge from these reflections can then be tested in other contexts, personal as well as professional, and students can be asked to synthesize competing definitions into a shared definition that can be posted in their residence hall, and one that can operate in the classroom.

The changes that we have made to our program over the years have had their own challenges, but we think the frustrations are becoming more and more productive as we develop, focus, and iterate our values. In moving towards a team-teaching model, for instance, this year we have merged our writing and engineering design courses into a single, two-quarter course. The design process now begins earlier in the year, is longer, and has been even more immersive. Writing projects have focused more on reflection than ever before, which students informally report as being helpful. However, by moving the design component earlier, our course on global sustainability has been moved to later in the academic year, and has been disconnected from the design process. This has meant that students have had less time to familiarize themselves with college and with campus before trying to define its unsustainable values, processes, places, and features—and, even more pragmatically, less time to know who they would and would not like to work with. Our attempted solution next year will be to convert all three courses into blended writing, sustainability, and design courses, with the focus moving from global contexts in the fall, to regional contexts in the winter, to greening-the-campus problem-solving in the spring. All three courses will be project-oriented and immersive, with as many real stakeholders interacting with us as possible. In the process, all sustainability content becomes contextualized, and writing becomes not only what we assess students on, as in most college writing courses, but how they assess themselves and us and each other.

As we work towards this revision, our next step is to flesh out the following assessment grid (Table 1), with each of our learning outcomes on the vertical axis, and identified stages of development on the horizontal axis (influenced by Perry's scheme of epistemological growth). The goal, then, is to reshape every experience and every assignment to enable students to develop to the best of their ability—and ours.

Table 1: Assessing achievement of HERE learning outcomes

This program participant	Novice seeing learning as external & absolute	Initiate seeing learning as individual & relative	Adept seeing learning as contextual & committed
recognizes in context, discusses, and demonstrates attitudes, behaviors and personal reflection about their rights and responsibilities to themselves, others, society, and the natural world			
recognizes in context, discusses, and demonstrates attitudes, behaviors and personal reflection about their habits and growth , as well as others', and the implications of these			
recognizes in context, discusses, and demonstrates attitudes, behaviors and personal reflection about their values and feelings , as well as others', and the implications of these			
defines sustainability in multiple ways and locates these definitions in historical, political, professional, and personal contexts			
defines, analyzes, and applies to their personal and professional lives basic concepts from ecology and environmental science			
recognizes, locates in context, analyzes, and evaluates cultural attitudes and narratives about the human relationship with the built and natural world			
comprehends, analyzes and explains the significance of basic politics of sustainability			
recognizes, analyzes, evaluates, synthesizes, and applies to their personal and professional principles for sustainable living			
defines, analyzes, and applies to their personal and professional lives basic concepts of environmental economics			
defines, analyzes, applies, and evaluates basic sustainability organizational concepts , including policies, practices, and values			
defines, applies, analyzes, and evaluates principles and tools of sustainable design			
defines, applies, analyzes, and evaluates basic sustainability metrics			

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