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A vision for advancing sustainability pedagogy in engineering through ethnographic design awareness

Dr. Royce A Francis, The George Washington University

Dr. Royce Francis is an Associate Professor in the Department of Engineering Management and Systems Engineering [EMSE] at the George Washington University. At George Washington, Dr. Francis's engineering education research explores the relationships between professional identity formation and engineering judgment. His other research interests include infrastructure resilience and risk assessment, and safer chemicals decision making.

Dr. Erica Cusi Wortham

Inspired by decades of work alongside Indigenous artists and activists, Dr. Wortham brings a concern for diverse, complex cultural and social contexts to her work at GW. She has built an interdisciplinary practice spanning art, design, social sciences an

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Abstract

The goal of this paper is to share a vision for enhancing sustainability pedagogy via a theory of ethnographic design awareness in engineering education. Ethnographic design awareness is way of knowing via design that centers lived experience, the interconnectedness of social and natural systems and the participation of diverse perspectives in building a sustainable future. This paper describes the theoretical support and work in progress for our Engineering for One Planet (EOP) mini-grant. The objective of our mini-grant is to design an undergraduate course and assignment that integrates systems thinking, engineering ethics, design justice, and the EOP sustainability framework through the lens of ethnographic design. This assignment, and the course it is situated within, are co-designed by an anthropologist who directs several design initiatives in the school of engineering and an associate professor of systems engineering at the authors' home institution. Our process includes implementation and evaluation of our assignment in the Spring Semester 2025. This paper reports our ethnographic design awareness framework and the structure of the course and assignment. By describing our theoretical support and preliminary assignment design, we hope to promote a vision for expanding ethnographic design methods in sustainable engineering pedagogy. Our conceptualization of ethnographic design awareness draws on wide-ranging influences including autonomous design, design justice, and inclusive design to re-imagine the ways that students engage engineering design practice at multiple levels.

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Keywords: Engineering for One Planet (EOP), ethnographic design, engineering design, autonomous design, design justice

1. Introduction

1.1 Overview and Rationale

There is a need for broad sustainability pedagogy in engineering education. Engineering educators for some time have recognized the outsized impact that human activities now have on Earth system processes and services. For example, in 2007 Allenby argued that engineers should be trained in skills that would foster the development of an Earth Systems Engineering and Management (ESEM) capacity (Allenby, 2007). While his argument focused on positioning civil and environmental engineering professionals as leaders in ESEM, his observation that "a world characterized by rapidly increasing integration of human culture, built environments, and natural systems to produce novel and complex emergent behaviors that are beyond traditional disciplinary structures and reductionist approaches" applies to all engineering disciplines (Allenby, 2007, p. 7961).

More recently, Schultz et al explicitly articulated the need for *all* engineers to be prepared in skills for sustainability (Schultz et al., 2023). To broadly support this aim, Schultz and co-authors introduced the Engineering for One Planet (EOP) toolkit to share proven tools for sustainability education broadly with engineering educators. They observed that while sustainability

curriculum has greatly expanded in engineering education, most engineering students still do not receive any instruction in sustainability. The EOP toolkit was jointly developed by the Lemelson Foundation, VentureWell Foundation, and the American Society for Engineering Education, and now includes several useful resources for engineering educators seeking to expand engagement with sustainability topics across curricula at their institution (Anderson & Cooper, 2022). These resources include the EOP Framework, a guide to teaching core EOP learning outcomes, a mapping between EOP learning outcomes and ABET student outcomes and the United Nations Sustainable Development Goals, a joint NSF-Lemelson program in the Research in the Formation of Engineers (RfE) portfolio, and the EOP mini-grant program.

The work in progress described in this paper is the subject of our EOP mini-grant in Cohort III. Our mini-grant project involved the development of a course, Impact of Technology on Society, with special focus on an assignment within that course, mini-ethnographies of situated technologies. First, the course is grounded in systems engineering and is designed to engage students in conceptualization of engineering design that foregrounds the potential roles of ethnography and sustainability in engineering design. Second, we devote particular focus to the mini-ethnography assignment that requires the students to conceptualize technological innovation ecosystems and designers' intentions by working backwards from field observations of a product, service, or process situated in the real world. Our mini-grant foregrounds the design and critical thinking elements of the EOP framework and guides students across disciplines to engage with ethnographic methods, case study methodology, personal reflection, and systems thinking to envision the social systems that produce novel products, services, or processes. Our hope is that students would better understand how representation, equity, and justice as enacted within the innovation ecosystem impact the extent to which the technologies those ecosystems produce foster sustainability, justice, and community resilience.

1.2 Significance and Paper Objective

Why is ethnographic design awareness important? First, it connects engineering students to the ways that design is experienced by users and goes deeper, facilitating awareness not only of design mismatches (Holmes & Maeda, 2018) but of the cultural biases and power dynamics embedded in all things designed. Second, it orients engineering students to critically assess the intentions of designers through their interpretation of the user experiences they learn to see through observation (fieldwork) and the culturally situated design logics that underpin them. Finally, ethnographic design awareness connects students to the opportunities and obstacles faced by engineering systems for improving sustainability. Therefore, the overall objective of this paper is to highlight the importance of integrating ethnographic design methods with sustainability frameworks like the EOP learning objectives. To this end, we also describe our ongoing work in progress integrating these frameworks and fields.

2. Sustainability + Ethnographic Design Awareness

2.1 Design + Anthropology → Ethnographic Design Awareness

Between the worlds of anthropology, design, and engineering there exist subdisciplines that inform our arrival to the concept of "ethnographic design awareness" as vital to engineering education. Among these, design anthropology is particularly salient. Design anthropology, sometimes referred to as "DA," may seem most resolved or uncontested in the United States within the context of business anthropology, where anthropologists participate on product development teams to identify "design ideas that fit the lived experience of intended

users"(Wasson, 2016, p. 8). In less transactional contexts where design anthropology more closely resembles its Scandinavian roots in participatory design, proponents of design anthropology have constructed a coherent set of principles that articulate invaluable orientations for engineering students engaged in design. For example, Christine Miller (Miller, 2018, p. 8) lists the following commitments for operationalizing design anthropology and evaluating projects:

- A commitment to a collaborative process that aims to achieve transdisciplinarity;
- A commitment to a participatory design that aims for the inclusion of a wide range of stakeholders;
- A commitment to an iterative design process;
- A commitment to ongoing methodological experimentation and rigorous critique;
- A commitment to a holistic approach that takes into account social, political, economic and other implications for people and the planet; and,
- A commitment to take into account both intended and unintended consequences of proposed designed artifacts.

Miller summarizes these commitments in a set of eight general criteria guiding design anthropological practice (Miller, 2018, p. 63): i) a transformative/future orientation thinking in terms of "future-in-the-making"; ii) a holistic orientation thinking in terms of systems and not isolated events; iii) collaboration to achieve shared vision iv) a transdisciplinary commitment to the unity of knowledge; v) a performative worldview that perceives people, things, and worlds as continuously and reciprocally in the making; vi) an emergent potentiality that takes into account the "continuous unfolding of possibilities and the implications for change on social, political, financial, economic and other dimensions for a broad range of stakeholders and for the planet;" vii) implementation of an iterative, design process–including a "willingness to rethink and revise to test assumptions throughout the process"; and viii) a critical perspective towards "each stage of the project to identify and evaluate intended and unintended consequences." Beyond bringing the user into the design process—the now familiar notions of "co-creation" and "co-design"—design anthropology applies the dominant methodology of anthropology, ethnographic fieldwork, to design in a manner that transforms ethnographic description into "correspondence:" "to correspond with the world, in short, is not to describe it, or to represent it, but to *answer* to it" (Gatt & Ingold, 2013, p. 144). This shift acknowledges that design is a conversation rather than a monologue.

In Designerly Ways of Knowing, design studies scholar Nigel Cross emphasizes that design is *exploratory*: "the creative designer interprets the design brief not as a specification for a solution, but as a kind of partial map of unknown territory … and the designer sets off to explore, to discover something new, rather than to return with yet another example of the already familiar" (Cross, 2006, p. 32). Insisting that the creative design process pass through ethnographic encounters allows designers to attune their work to the emergent quality of design solutions where "the solution and the problem develop together" within, not extracted from, complex social and ecological contexts (Ibid). The emergent, exploratory character of design process also throws how we come to know things into relief. The "imperfect data" gathered in ethnographic fieldwork asks engineering students and educators to "embrace the social turn" and grapple with "how they know what they know," which through facilitated discussion, can productively settle and unsettle epistemological confidence in the context addressing ill-defined problems (Miranda et al., 2022).

An ethnographic approach to engineering design goes beyond establishing "empathy" for the real or imagined user. Not only does it insist generally on broad and deep contextualization within social and/or ecological systems, an ethnographic lens places technology within a cultural context. Technologies are often assigned a false neutrality, placing them beyond accountability and critique; ethnographic design awareness helps to resituate technologies as necessarily shaped by cultural constructs in a way that extends to technologists and designers as much as end users. In addition, anthropology's disciplinary acumen for putting power dynamics into relief lends ethnographic design awareness a critical perspective often missing in engineering education (Claris & Riley, 2012). Following Kate Crawford's example, if we situate artificial intelligence technology as fundamentally social and political, "we need to go beyond neural nets and statistical pattern recognition to instead ask *what* is being optimized, and *for whom*, and *who* gets to decide" (2021, p. 9). Bolstered with contemporary frameworks such as design justice, ethnographic design awareness is predicated on the "full inclusion of, accountability to, and ultimately control by people with lived experience of the conditions the design team is trying to change" (Costanza-Chock, 2020, p. 99).

Sasha Costanza-Chock, Professor of Civic Media at MIT, opens a chapter in Design Justice: Community-Led Practices to Build the Worlds We Need with a quote that sums up why attention to power dynamics is essential: "'Today the tech industry does not look like America, and that has a significant influence on the types of products and services that get created … When the lived experience of underrepresented communities is omitted from the product development cycle, the usefulness of the technology becomes biased toward one group'" (Costanza-Chock, 2020, p. 70). Our work to incorporate ethnographic design awareness into engineering education as a foundational sensibility is also connected to our efforts to address the low representation of communities of color in the engineering classroom. First, we use Costanza-Chock (2020) to introduce students to the ways that the "matrix of domination" (p.71) has limited who may participate in the role of technologists and designers according to prevailing structural inequities (racism and sexism or, more specifically, white supremacy and heteropatriarchy). Furthermore, students' engagement with Costanza-Chock foregrounds the ways that "tech companies reproduce intersectional oppression through their hiring practices; through internal corporate culture that tolerates misogyny, racism, and sexual harassment; and through the products they design" (p.71). Remixing these ideas with ethnographic design awareness, we can "spur our imaginations about how to move beyond a system of technology design largely organized around reproduction [of the matrix of domination]. In its place, we need to imagine how all aspects of design can be reorganized around human capabilities, collective liberation, and ecological sustainability" (Costanza-Chock, 2020, p. 72). More than consultation, design justice moves end users and user communities to positions of control, in the design process and in terms of shared ownership (Costanza-Chock, 2020, p. 101).

Renowned Colombian anthropologist Arturo Escobar—whose first degree incidentally is in chemical engineering—caps our theoretical support for ethnographic design awareness with his work on autonomous design in Designs for the Pluriverse: Radical Interdependence, Autonomy, and the Making of Worlds. Building on many decades of critique of the "first" world's model of development and globalization (Escobar, 2012), his turn to design situates our contemporary global crisis as a crisis of a "particular *modelo civilizatorio* or civilizational model of patriarchal Western capitalist modernity" (Escobar, 2018, p. ix). Escobar points out that development discourses typically proceed from Western modernist/dualist assumptions. These assumptions assert a "One World World" (OWW) hegemony that privileges/prioritizes certain economic and

political orientations, thereby marginalizing or oppressing others. He argues that OWW dominance literally "de-futures" entire ways of being, with operationalized development discourses and prevailing approaches to design "aimed literally at scrapping the vernacular design and endogenous practices that for centuries had nourished, for better or worse, the lives of millions throughout the centuries" (Escobar, 2012, p. 6). Moreover, Escobar observes that the structures of unsustainability maintaining the "dominant ontology of devastation" must be confronted in a world transformed by changing climate and the need for economic transitions.

Escobar tracks activists, designers and scholars who are enacting a civilization model that liberates Mother Earth and is built on relational ways of knowing, being and doing. A key framework for design in his view is called autonomous design. As a design praxis *with* communities, autonomous design centers five principles, shortened here with emphasis by the author:

1. Every community practices the design of itself via its organizations, its social relations, its practices, and its relation to the environment.
2. Every design activity must start with the strong presupposition that people are practitioners of their own knowledge; from there, design activity must examine how people themselves understand their reality.
3. What the community designs is an inquiring or learning system about itself. As designers, we may become co-researchers with the community, but it is the community that investigates its own reality in the codesign process.
4. Every design process involves a statement of problems and possibilities that enables the designer and group to generate agreements about objectives and to decide among alternative courses of action.
5. This exercise may take the form of building a model of the system that generates the problem of communal concern. Problem statements always imply solution statements; problems never stand as neutral statements about reality. → The entire process is political since any construction entails choices that affect people in particular ways. (Escobar, 2018, pp. 184–185)

The question that every autonomous design project must face is: what can we do about it? Autonomous design aims to facilitate/foster "a diversity of modes of living that would acknowledge both memory and the inheritance from the past as creation" (Escobar 2018, p.13) requiring a new technical rationality that enables the embodiment of the five realities of conviviality in local worlds. This new technical rationality requires the acknowledgment that human reality is *relational*, and relationships among the various dualisms between peoples and planetary systems (e.g. nature/culture, West vs. the rest, subject/object) must be accommodated in any approach to design and ways of being.

Ethnographic methods are uniquely suitable for helping designers situate their work in these relational processes. Moreover, considering design justice and autonomous design, the imperative of an ethnographic approach to sustainability lies in its ability to bring an experiential, tangible lens to understanding processes often deemed too distant or disconnected to grasp (and thus answer). The ethnographic approach makes visible how interconnections among broad socio-technical systems and Earth systems are experienced in everyday life. Settling on the notion of "ethnographic design awareness" allows us to emphasize a mindset or expansion of knowledge that students can bring to open-ended and ill-defined problems. As

Cross and others argue, and we agree, design ability is "a fundamental aspect of human intelligence" (2006, 15). The "universality of design as a human activity" (Costanza-Chock, 2020, p. 73) undergirds the imperative to build diversity among design professionals as well as to take seriously design contributions of (non-professional) community members. It follows that we are all designers, but somehow many of us forget that "everything we have around us – our environments, clothes, furniture, machines, communication systems, even much of our food – has been designed" (Cross, 2006, p. 15). This awareness opens the possibility for design education to address the environmental urgencies of our time. If everything around us is designed, we can collectively design things to support a sustainable future.

2.2 Sustainable Engineering Design

Design is critical to the attainment of sustainability because the failure to create sustainable societies is directly due to our failure to create sustainable design practices. This urgency is suggested by the direct language of the Engineering for One Planet (EOP) definition of sustainability: "Designs, practices, innovations, technologies, methodologies, etc., that mitigate negative impacts and/or enable increased positive and regenerative impacts on environmental and social systems" (Anderson & Cooper, 2022). And yet, design practices are rarely taught to their full transformative potential; some majors may learn how to "CAD," but engineers rarely consider themselves "designers" adept at tackling open-ended problems. Ethnographers who have merged field research methodologies with design practices argue that "design has arguably become one of the major sites of cultural production and change, on par with science, technology, and art"(Gunn et al., 2013). Escobar (2018) and many others affirm that design is a way of being in the world. It is fundamentally ontological. Moreover, everyone is a designer, and "design designs" (Willis, 2006)—that is, design shapes our world and our world shapes us. If our way of being in the world is unsustainable, it is because our approaches to design are making sustainability impossible. We must re-evaluate everything about current approaches to sustainability. Our philosophical assumptions, technological practices, and economic extractivism (Crawford & Joler, 2018) driving most of our technological systems must be deconstructed and something new must take their place.

The Engineering for One Planet (FOP) framework, jointly crafted by the Lemelson Foundation, VentureWell, and ASEE in 2022 is described as a "practical implementation tool to help educators embed sustainability into engineering education" (EOP 2022). The "one planet" the framework envisions is not unlike the "pluriverse" Escobar and others enact. Connecting social and environmental concerns, the EOP framework insists that to create a "healthy, flourishing world" engineers "must understand the history and implications of racist, classist, and patriarchal practices in engineering and social systems, and be prepared to help eliminate these practices…[and] be prepared to help engender environmental justice" (Anderson & Cooper, 2022, p. 4). To help achieve this, the framework authors identified six advanced learning outcomes in the design category that engineering educators can implement. All six align directly with what we aim to achieve with ethnographic design awareness:

1. Recognize local craft traditions, indigenous knowledge systems, and vernacular practices, and innovate inclusive and regenerative solutions and processes
2. Implement stakeholder user experience/participatory studies (e.g., design thinking, human centered design) and social impact assessments to meet user needs in responsible, novel, improved, ethical, and sustainable ways

3. Design with approaches that incorporate whole life-cycle and systems thinking
4. Develop creative trans-disciplinary ideas and solutions in engineering contexts along with social and cultural values (e.g., habitat, construction, and health that is attuned to and respectful of social values, etc.) by working across disciplines
5. Design with systems dynamics concepts in mind (e.g., feedback loops, complex cause-effect chains, cascading effects, inertia, tipping points, legacy, resilience, adaptation, etc.)
6. Create solutions for use with alternative business models and emerging economic contexts (Anderson & Cooper, 2022, p. 19)

3. Work-in-Progress: EOP Mini-Grant Project Context and Objectives

3.1 EOP Mini-Grant Project Overview

Our approach to teaching ethnographic design awareness to engineering students is enacted in an ongoing EOP Mini-Grant. The objective of our mini-grant project is twofold. On the one hand, our mini-grant project involves the development of a course, Impact of Technology on Society that centers design; and on the other hand, it involves the refinement of an assignment within that course where the students create mini-ethnographies of innovation ecosystems. This course is designed for students across engineering majors at GW after their first year of study, and for students in their third or fourth year of the sustainability minor. The course engages students in a critical conceptualization of engineering design that foregrounds the role of judgment, representation, and justice. Within this course, we especially devote focus to hands-on introduction to ethnographic methods using a mini-ethnography assignment that requires the students to explore how a product, process, or service is embedded within cultures, systems of meaning creation, and ecological and technological systems. Consequently, our mini-grant focuses on the design elements of the EOP learning objectives framework.

3.2 EOP Learning Objectives

Restricting the focus of discussion to the assignment for the purpose of this paper, the overall objective of the mini-ethnographies assignment is that the students will address the question "Is this system (or technology) human-centered or enterprise-centered?" As students engage this assignment in the course, they are prompted to think about the following themes and their connections to the readings and discussions that we will have engaged to this point in the course:

- *How does this system/technology enable or inhibit sustainability*? (EOP Core Outcomes 1,3; Advanced Outcomes 4,5) — Sustainability has emerged from remote observations of atmospheric temperatures and ice caps to the strategic discussions of boardrooms and financial engineering products. It is now mainstream, but what does it mean to be sustainable? What is our role in attaining sustainability? How does technology help us? How does technology make our situation worse? The students are guided to construct a definition of sustainability to use to explore the system/technology the students select. The students then utilize this construction as our starting point for direct ethnographic observation.
- *Whose problems produced this system/technology*? Whose problems were solved? (EOP Advanced Outcomes 1,2,4,6) — After some preparatory work exploring the use of ethnographic case study methods, students will visit or observe the system/technology and talk with workers, make observations, and discuss their visit in a short debriefing discussion. Using their observations, we will explore the broad question of "Is the

system/technology human-centered or enterprise-centered?" As the students think about the system, we think about the vision of society and the community that produced the concept, the society and community it enables, and how these connect to broader societal goals of sustainability and coherence.

These learning objectives and questions for engagement help to ground our course and its assignment in what we are called above an "ethnographic design awareness" framework.

3.3 EOP Project Implementation, and Prospective Evaluation

The overall course has four units:

- Unit 1: Ethics, Socio-technical systems, and Value systems (3 weeks)
- Unit 2: Technology Mapping (5 weeks)
- Unit 3: Sustainability and Systems Field Work (3 weeks)
- Unit 4: Student Choice Projects (3 weeks)

The mini-ethnographies assignment is conducted during Unit 3. During the first week of Unit 3, the students are provided with the assignment prompt and given a brief introduction to ethnographic field methods which build on a series of ethnographic design awareness activities designed to hone their skills and build their design vocabulary over the course of the first two units. Students are directed to readings in field methods and human-centered design, and they are required to submit written reading responses before the class session where the ethnographic methods primer is presented. During the second week of Unit 3, the students are released to conduct their fieldwork. This year's course, the students are exploring the relationships between Pharma, Food Systems, and Sustainability. In this version of the course, they are given the following brief description of the fieldwork: "The overall objective of Unit 3 is to investigate the use of Ozempic and similar GLP-1 regulating drugs through ethnographic fieldwork at one or two local sites that are active in the broad socio-technical-ecological system that connects pharma, sustainability and food systems: grocery/convenience stores and/or dining halls in different socioeconomic contexts in the District of Columbia. Our fieldwork will address the question, 'In what ways is the use of GLP-1 regulating drugs human-centered or enterprise-centered?'"

To guide their fieldwork, we have prepared two broad guiding questions for the students:

a. *How does technology enable or inhibit sustainability?* Sustainability has emerged from remote observations of atmospheric temperatures and ice caps to the strategic discussions of boardrooms and financial engineering products. It is now mainstream, but what does it mean to be sustainable? What is our role in attaining sustainability? How does technology help us? How does technology make our situation worse? While GLP-1 drugs are primarily considered tools in our arsenal against obesity, what sustainability impacts do you envision they might have?
b. *Whose problems produced the GLP-1 regulating drugs? Whose problems were solved?* After some preparatory work exploring the use of ethnographic case study methods, we will send you off to talk with stakeholders (e.g., GLP-1 users and their family members), visit grocery stores, convenience stores, dining halls, residences, and other places where food is sold or consumed, make observations of media mentions of Ozempic and GLP-1 drugs, and debrief your observations with your peers. Using your observations, we will explore the broad questions of the ways engagement around these drugs is human-

centered or enterprise-centered?" As we think about the interconnected systems brought together by these drugs, we can think about the vision of society and the community that produced them, the ways they may support society and community, and how these drugs are connected to broader societal goals of sustainability and health.

Students present the results of their fieldwork in week 3 (the presentation format is not predetermined). This assignment is intentionally open-ended, and is intended to be broadly responsive to the interests and skills each student brings to the course. The only requirement is that each student is prepared to present the results to the rest of the class. For example, during a pilot version of the course, the topic of Unit 3 was the intersection of machine learning and food systems, and our fieldwork was conducted at an Amazon "Just Walk Out" Whole Foods Market. The students and we all wrote reflective essays about our experiences and discussed our experiences and observations at the following class session.

Since the mini-ethnographies assignment will not have been observed before this paper has been submitted, we do not have student or instructor experiences with the course and assignment to report in this paper. However, we do anticipate conducting semi-structured interviews and short surveys with the students who take the course so that we can evaluate the impact of the mini-ethnographies assignment on students' engagement with our ethnographic design awareness framework and the EOP learning objectives.

4. Conclusion

In conclusion, creating an approach to ethnographic design awareness is a significant opportunity for advancing sustainability pedagogy. First, ethnographic design awareness foregrounds the role of design in creating our worlds and ways of being in those worlds. If our ways of being are unsustainable, fostering a new approach to engineering design that centers relationality and sustainability is key to advancing more sustainable ways of being. Second, ethnographic design awareness has the potential to transform engineering educational institutions by infusing sustainability across disciplines with attention to communities and diverse lived experiences. Finally, ethnographic design awareness highlights the ways that technologies are immersed within culture and meaning-making processes. Engineers who develop ethnographic design awareness will obtain a critical perspective that will help them to anticipate and account for the intended and unintended consequences of their designed works. We encourage engineering educators to consider adoption of ethnographic design techniques that incorporate sustainability into their program educational outcomes and methods.

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