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Teaching students to collaborate with communities: expanding engineering education to create a sustainable future

Jennifer Hirsch^a, Ruth Yow^a and Yi-Chin Sarah Wu^b

^aCenter for Serve-Learn-Sustain, Georgia Institute of Technology, Atlanta, USA; ^bOffice of Academic Effectiveness, Georgia Institute of Technology, Atlanta, USA

ABSTRACT

Engineers are crucial to solving the world's most pressing challenges, but they cannot do it alone. Creating new and more just systems that support people and planet requires that engineers learn to engage with diverse stakeholders as equal partners. This article shares how the Serve-Learn-Sustain (SLS) initiative at the Georgia Institute of Technology has been introducing new approaches to problem-solving into engineering and technology-focused education to better prepare students to address the sustainability challenges of our moment, in collaboration with community partners, especially those from historically marginalized communities of color. To do this, SLS focuses on de-centering academic expertise and positioning community partners as experts, innovators, and co-educators. The activities and impacts described here, including course-based collaborations with community partners and co-curricular social innovation programs, have implications for other higher education institutions that recognize the importance of partnering with communities to prepare students to use their education to effect change.

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Introduction: towards a new approach to engineering problem-solving

In the last few years, the National Academies of Sciences, Engineering, and Medicine have published a number of reports pressing for significant changes in curricular design to better prepare students to address the complex challenges of our time, such as climate change. Coined 'wicked problems' in 1973 by Rittel and Webber¹, these challenges are characterized by interdependencies, uncertain facts, high stakes, conflicting stakeholder values, inadequacy of scientific data, and a sense of urgency to avoid irreversible human and planetary damage. These reports argue that students need to learn more systemic approaches to problem-solving, in part by receiving more applied learning, across disciplines and with real-world partners, that teaches them to engage collaboratively with multiple stakeholders. For example, in *Environmental Engineering for the twenty-first Century*², the National

CONTACT Ruth Yow  ruth.yow@gatech.edu  Center for Serve-Learn-Sustain, Georgia Institute of Technology, Atlanta, USA

Academies argue that engineering education needs to combine technical and social competencies and be connected to a civic agenda. In *Strengthening Sustainability Programs and Curricula at the Undergraduate and Graduate Levels*³, the National Academies emphasize the importance of interdisciplinarity, diversity, and applied learning in creating sustainability education programs that prepare students to effect change.

Many of these ideas are not new and do not meaningfully challenge the neoliberalization of academia. For example, analyzing a case study from the University of Botswana, Tabulawa argues that interdisciplinarity was used to 'break academics' monopoly on the processes and products of higher education to form new academic identities and subjectivities that reflect a corporatist ethos' and 'support the needs of a market-based economy'.⁴ Similar arguments can be made about concepts such as diversity and equity as well as applied learning. Building on the critiques advanced by scholar Sirma Bilge of what Bilge deems the 'neoliberal equity/diversity regime', Smele *et al.* write that 'within higher education ["the diversity regime"] both neutralizes and seeks to profit from what are portrayed as harmless "differences" between groups of people'.⁵ Teaching in the context of that very regime, the authors 'challenge both students and educators to consider which oppressions are being entrenched or reproduced even within our attempts to foster socially justice-oriented classrooms'.⁶ As Smele *et al.* attest, the best intentions of well-equipped teachers can be subsumed into a broader edifice that seeks to standardize – and then monetize – diversity and equity curriculum.

Exposure to non-STEM perspectives is particularly crucial given that topics such as community, race, equity, and power are generally taught only in liberal arts courses, which engineering students typically take solely to satisfy the minimal general education requirements. We are clear-eyed about the fact that some engineering students will be advantaged by including some 'diversity and equity'-focused curriculum and project experience on their résumés while never actually gaining an in-depth understanding of these concepts as they are practiced in their fields. But we proceed with the awareness that exposing engineering students to, for example, the work of community partners who are grassroots organizers can deepen otherwise surface-skimming references to concepts such as 'community' and 'stakeholders'.

Furthermore, at the level of the academic unit or institution, focusing on 'diversity and equity' serves as a way to educate students on systemic injustice and the complicity of the technical disciplines without sounding alarms in a conservative university system. In disciplines such as civil and chemical engineering, minor tweaks that would raise no eyebrows, like using a case study focused on black community leaders responding to the impacts of flooding or chemical waste in their community, can lead students to a closer analysis of their discipline's impact on actual communities. They can begin to understand how, for example, their technical skills intersect with policies and processes that disadvantaged black residents by relegating them to low-lying flood-prone properties or homes adjacent to chemical plants.⁷ In sum, we agree with Shove and Walker, who, at the end of an article urging policymakers and academics to be skeptical of efforts aimed at changing 'sociotechnical regimes', nevertheless conclude that we really have no alternative other than to keep trying.⁸

In particular, we focus on teaching students the skills to create what Funtowicz and Ravetz refer to as 'extended peer communities' that invite in divergent perspectives on a given issue and then work across the boundaries of traditional disciplines, fields, sectors,

and areas of society.⁹ Funtowicz and Ravetz especially emphasize the importance of including laypeople – the groups most impacted by the problems – in research and decision-making. They write:

Those whose lives and livelihood depend on the solution of the problems will have a keen awareness of how the general principles are realized in their ‘back yards.’ They will also have ‘extended facts,’ including anecdotes, informal surveys, and official information published by unofficial means. It may be argued that they lack theoretical knowledge and are biased by self-interest; but it can equally well be argued that the experts lack practical knowledge and have their own unselfconscious forms of bias.¹⁰

Writing specifically about engineering education, Verrax argues that engineering ethics and teaching need to expand to focus on technology in the context of the ‘ordinary’, rather than focusing almost solely on ‘disaster ethics’ related to ‘Big Technology’, writing: ‘Technology as the texture of our everyday life demands practical guidance.’¹¹ Lucena *et al.* argue that engineering education must evolve to teach students to collaborate with community members, given the traditional grounding of engineering in industry, its privileging of scientific expertise, and the dearth of courses that teach the relationship between engineering and power.¹² They argue that this requires moving away from the traditional Engineering Problem Solving (EPS) methodology, which they claim fails to equip students to work collaboratively because it cordons off a ‘technical’ problem at the expense of historical and cultural context.¹³ They also explain that EPS leads students to view problem solving as a linear sequence, when in fact it is often characterized by negotiation and improvisation.

The work of scholars such as Gary Downey and Gwen Ottinger bridges humanities and engineering audiences and charts a path forward for theorizing and enacting the transformation of engineering education. Downey points to ‘the practices of collaborative problem definition’ as central to ‘scalable scholarship’ rather than piecemeal adjustments; he posits that critical analysis must be intrinsic to engineering curriculum and argues for placing problem definition and problem solving ‘alongside’ each other.¹⁴ In Ottinger’s complementary view, intentionally sharing expertise produces new ways of interacting and collaborating outside of a client-consultant or client-provider model.¹⁵ Challenging the widely-held notion that scientific knowledge is ‘predictable and enduring’, Ottinger instead asserts its mutability as a ‘cultural creation, made and remade through the daily practices of scientists and engineers’.¹⁶ Ottinger’s belief that engineers can refashion their relationship to knowledge, problem solving, and the communities with which they collaborate in great part guides the work described here.

Serve-Learn-Sustain (SLS), a program at the Georgia Institute of Technology where all three authors work, has been introducing new approaches to problem solving into engineering and technology-focused education to better prepare students to tackle our gravest challenges. We do this by facilitating course and student collaborations with community partners that de-center academic expertise and position community partners as experts, innovators, and co-educators. Our assessments have indicated that (1) students come to appreciate the expertise of partners and understand how they can contribute their own skills to community-based work; (2) students gain understanding of the importance of community history and context; and (3) SLS initiatives such as the internship program regularly influence students’ career aspirations, and they express newfound interest in exploring jobs that involve working with community partners on projects that advance equity and justice.

About Serve-Learn-Sustain

SLS was launched in 2015 as the Institute's Quality Enhancement Plan (QEP),¹⁷ with the Provost's Office committing \$6M to the initiative over five years. As a requirement of accreditation under the Southern Association of Colleges and Schools Commission on Colleges (SACSCOC), QEPs are five-year initiatives intended to enrich the undergraduate curriculum around a specific theme, in this case, 'creating sustainable communities'. SLS's primary charge is to engage students and faculty in community-based partnerships aimed at advancing sustainability in communities across Atlanta and Georgia. With the QEP complete, SLS is now institutionalized as a regular unit in the division of Undergraduate Education at Georgia Tech.

From the beginning, SLS has challenged Georgia Tech to approach sustainability as a holistic issue. The QEP defined 'sustainable communities' as 'places where people want to live and work, now and in the future. They meet the diverse needs of existing and future residents, are sensitive to their environment, and contribute to a high quality of life'.¹⁸ In practice, the SLS initiative has pushed Georgia Tech to center the social aspects of sustainability. These include equity and justice issues that are generally either ignored or tacked on as 'co-benefits' to primary foci related to environment or economy, as well as process issues related to how faculty, students, and staff understand and collaborate with partners. Illustrative of our approach is the first new course that Serve-Learn-Sustain offered: Technology and Sustainable Community Development, co-taught by author Yow with a computer science faculty member. This project-based course introduced students to the history of engineers' and STEM professionals' complicity in neo-colonial development projects in countries where the depredations of colonialism had created the conditions that Western professionals sought to ameliorate.¹⁹ By supporting these students in developing a critical vantage point on the role that engineers have played in disempowering local communities and disregarding local knowledge, we positioned students to meet the primary goal of the course: to undertake their project work with respect for community partners' expertise and to see their own work as contributing just one piece to an ongoing, long-term effort led by their partners.

Overall, SLS has designed an approach to community sustainability partnerships that draws on three foundational frameworks: (1) equity and justice, (2) asset-based community development, and (3) democratic social innovation. SLS's partnership principles, programs, and intellectual foundations bear the mark of scholar-activist movements that take equity and justice as key to creating sustainable communities, such as the environmental justice, climate justice, and 'just sustainabilities' movements, launched and led by well-known figures such as Robert Bullard, Beverly Wright, and Julian Agyeman.²⁰ Relatedly, we practice critical – rather than traditional – service learning, which takes service as a starting point for introducing students to systems of inequality and guides them in exploring the question of how injustices created the need for service in the first place.²¹ The arrival of critical service-learning frameworks has led university-based practitioners like us to carefully consider both whether service-learning pedagogy centers equity and justice, and to co-create collaborations that recognize the burden – in time, energy, and other resources – that service learning places on small community organizations. It is important to note that even service-learning models that do not have an explicitly critical orientation – that is, an orientation engaging structural inequality and power as fundamental contexts – have contributed to a robust discourse around the role of community partnerships in engineering education.

Mary Beth Lima's work demonstrates how a professor's reflective praxis in guiding service-learning projects can advance the field. She insists that students gain an understanding of the 'community's history and culture' and develop an 'aware[ness] of [their] own stereotypes'.²² The civic emphasis of Lima's service-learning pedagogy has implications for the kinds of professional engineers she hopes her service-learning courses will produce. As she writes, 'engineers work with community partners in a democratic sense, where there are services exchanged for the common good of people in the community'.²³ In a piece documenting a playground construction collaboration over the course of more than a decade, Lima asks, 'What do we want the trajectories of our graduates' lives to look like as professionals and as engaged citizens?'²⁴ Lima's question motivates our work as well, in conjunction with our attention to the way that that universities have, under the guise of collaborations that ostensibly 'serve' partners – but ultimately benefit students – extracted the unremunerated labor and wisdom of community-based leaders and groups. Later in this discussion, we profile one of our signature community partnerships and outline the ways that SLS's approach to relationship-building reflects an attempt to address the 'growing dissatisfaction [among community partners] with service learning since the late 1990s' documented by service-learning scholars such as Styron and Stoecker.²⁵

To this central focus on equity and justice, we add a foundational emphasis on asset-based community development (ABCD), which engages communities based on their assets or strengths rather than their deficits or problems. ABCD teaches students to switch from the question – 'how can I fix this community?' – to the question – 'how can I support and mobilize the gifts of community members in realizing the change they want?'²⁶ Finally, we employ a social innovation framework that situates community partners themselves as the experts and innovators. Smith explains that while innovation is not traditionally associated with citizen engagement, in fact, '[h]istorical experience suggests interventions for social development work best and endure longest when they build upon processes of citizen participation, open deliberation and sensitive community development'.²⁷

Key to SLS's mission and programs is creating learning experiences that equip students to understand themselves as collaborators rather than problem-solvers and to embrace opportunities to learn from community partners. In keeping with best practices in community partnerships with universities, we emphasize the importance of building long-term, collaborative relationships rather than short-term, project-based, transactional ones.²⁸ SLS programs attempt to teach this reorientation to both students and faculty. Collaborative learning and problem-solving environments challenge an 'engineering identity'²⁹ wedded to the EPS methodology that suggests there is a single path to a 'right' and 'neutral' solution.³⁰ This focus on collaboration seems particularly important in the context of engineering education, which emphasizes that expertise lies in formal institutions and that technology – too often scrubbed of its complex social context – will solve the world's problems.³¹

Community collaborations and the expanded boundaries of expertise and innovation

Engineering education at Georgia Tech and elsewhere has a strong emphasis on technology as a solution and on engineers as the experts to deliver that solution. SLS has approached community partnerships around sustainability as an opportunity to expand

Georgia Tech's educational approach to expertise. In this section, we describe how this approach plays out through two programs: (1) course-based collaborations with community partners and (2) co-curricular social innovation programs. Like the majority of SLS's work, the examples below focus on work that we do with Black-led community-based organizations. Furthermore, they focus on organizations with which SLS has long-term partnerships, meaning they engage with SLS programs over multiple semesters and years on collaborations that advance a long-term, community-driven vision.³²

Program 1: course-based collaborations with community partners

Since its doors opened in 2015, the primary goal of SLS has been to assist faculty teaching in all six colleges across campus in incorporating the theme of 'creating sustainable communities' into their courses. The primary program that SLS developed to advance that goal is the Affiliated Courses Program, through which faculty request affiliation for courses they teach that already cover some aspect of the theme or that they want to re-design to address it. SLS faculty and staff then market the course to students and provide affiliated faculty with support to deepen content related to sustainability and community engagement – and especially social sustainability, including equity and justice – through workshops, individual advising, and an online Teaching Toolkit with over 60 original tools. SLS has also awarded over \$500,000 in faculty course development grants. The Affiliated Courses Program launched in Spring 2016 with just 11 courses, primarily in Liberal Arts, enrolling just under 300 students. In AY2021, SLS affiliated 118 courses across all six of Georgia Tech's colleges, taught by 81 faculty members and enrolling approximately 4600 students (28% of the undergraduate population).

Given SLS's focus on communities and service learning, much of its work involves facilitating course-based projects with community partners. We structure these relationships as 'extended peer communities' in which community leaders are positioned as 'community professionals' and the communities themselves are introduced to the faculty and the students based on their assets. We have been referring to partners as 'community professionals' since we were introduced to the term by a partner from the Proctor Creek Stewardship Council on Atlanta's westside, who created it to acknowledge and honor the expertise that partners bring to the table. It is also important to recognize that community members often bring to the table field-specific expertise, based on their educational and career backgrounds. This term can cover these types of expertise as well.

The next section describes one particular partnership and project, to demonstrate how SLS's approach plays out in practice.

Example partnership & project: trash traps with West Atlanta Watershed Alliance (WAWA)

Trash Traps is a project brought to SLS by two community organizations – the West Atlanta Watershed Alliance (WAWA) and Groundwork Atlanta – that both work in west Atlanta, a largely Black and low-income area of Atlanta that abuts Georgia Tech. Established in 1998, WAWA states on its website that it aims to 'improve the quality of life within the West Atlanta Watershed' by both 'protecting, preserving and restoring our community's natural resources' and 'represent[ing] African American neighborhoods in Northwest and Southwest Atlanta that are most inundated with environmental stressors, but are

least represented at environmental decision-making tables'.³³ WAWA was formed by older community members, with support from volunteers around the Atlanta region. Their work is grounded in the tie between people and place, drawing on the way that local waterways have played important roles ecologically and culturally in the vitality of westside communities. Groundwork Atlanta, also a community-based organization focused on west Atlanta, was established in 2015 as a local 'trust' in the Groundwork USA network, to, as its website states, 'bring about the sustained regeneration, improvement and management of the physical environment by developing community-based partnerships which empower people, businesses and organizations to promote environmental, economic and social well-being'.³⁴ Both WAWA and Groundwork have been engaged in long-term projects connecting creek clean-up to ecosystem health and workforce development, in collaboration with Coca-Cola and small companies in the Southeast that produce trash traps for polluted waterways.

In Spring 2019, SLS connected faculty members from Georgia Tech's Civil and Environmental Engineering Capstone program to WAWA and Groundwork along with a federal government agency to assist with siting trash traps along Proctor Creek, a key waterway in the local watershed. The hydrology-related knowledge and skills required of students complemented the community-grounded knowledge and leadership offered by WAWA and Groundwork Atlanta. The project's specific intervention – siting traps along the creek – drew on technical skills related to environmental engineering; additionally, it aligned with the community organizations' broader workforce development goals, namely, establishing a career pipeline of sustainability professionals from, and working for, west Atlanta as well as creating small upcycling businesses. To better understand Proctor Creek's geographical and social context, the students visited the site and learned about its specific cultural history from WAWA's staff and community elders who have long led local mobilization efforts – via WAWA and other organizations – around watershed health. WAWA has helped to create and lead several local networks of residents and coalitions of environmental justice organizations; hence, they are uniquely well-positioned to be one of SLS's primary partners in educating students about environmental history and justice in west Atlanta.

Through meetings with WAWA and Groundwork, students also became familiar with how critical – and fruitful – it is to engage diverse forms of expertise, especially in the context of a project with major corporate funders and small grassroots organizations. Students came to understand their role as one of collaborator and co-learner in the context of an extended peer community, rather than solely as problem-solver, offering a solution to a technical problem. Students saw that necessary expertise came from diverse perspectives, through community-based interactions with elders in the surrounding neighborhoods who remembered the pristine creek of their childhoods, as well as discussions with staff at the Department of Watershed Management, who had been, in tandem with American Rivers, helping to support the restoration and protection of the health of Proctor Creek. Additionally, SLS provided the student team with a 'subject matter expert' – an environmental historian who met with them to help them make broader connections around environmental justice and sustainable development in the Southeast and in Atlanta particularly. Finally, the student engineering team and their faculty mentor presented to other members of the Georgia Tech community and to an array of SLS collaborators in the context of an 'SLS Think Tank'. This event provided students with an opportunity to understand linkages between well-sited trash traps, local workforce development, and the possibility of a

resulting circular economy in which trash removed by local trainees is sorted and kept in the community to be made into a marketable good. In the winter of 2019, the community organizations involved in the project convened in a special ceremony held along Proctor Creek to celebrate the placing of the traps and the way in which the project brought together government, corporate, community, and university collaborators to advance the vision of a cleaner, safer watershed for west Atlanta communities.

When it comes to supporting the (often divergent) visions of local community members, the fantasy of technological solutions bestowed, like gifts, to grateful community members is shattered by working in communities with Black leaders who have long histories working with predominantly white institutions like Georgia Tech. These community-based advocates and leaders clearly convey, as they introduce students to their neighborhoods, that understanding the history of red-lining is as central to the success of a watershed-focused project as understanding velocity and percolation. WAWA has been an ideal mentor in course-based projects as well as in experimental and innovative research and education projects, such as SLS's Public Interest Technology (PIT) Program. The PIT program prepares engineering students to be able to incorporate deep community engagement into their technology-focused careers. More broadly, WAWA was a founding member and leader of our United-Nations-acknowledged sustainability network and is collaborating with SLS and other leading organizations in the region from the network to develop a multi-stakeholder community science network that aims to leverage existing assets in the community and advance long-term community science research efforts driven by community priorities.

SLS works with WAWA and other partners as co-educators by engaging them in setting the parameters for partnership. For example, the honoraria that SLS pays to partners for various types of engagements are amounts that partners have discussed and weighed in on with us, helping us shape an equitable payment structure. This kind of transparency is particularly important in these multi-valent partnerships with organizations like WAWA, in which full-time staff may number only three or four people, all of whom are engaged with some aspect of research, co-teaching, mentoring, project development, and advocacy with Georgia Tech faculty and students (and students at surrounding institutions). It is through these partnerships – in which community-based leaders not only serve as dynamic educators, but also show us our institution and its resources in new lights – that we encounter social innovation not just as a variation on entrepreneurship but as a way of re-imagining how higher education institutions and community organizations might forge new modes of education and professional development for students of technology.

Program 2: co-curricular social innovation programs

A key focus right now in higher education overall, innovation is especially emphasized at STEM institutions, which often position themselves as leaders in innovation education. Georgia Tech is no exception: innovation is at the core of the institution's identity, and technological innovation has been a key focus of sustainability education and research at Georgia Tech. Thus, since its inception, SLS has focused on tapping into the energy around innovation to support, establish, and grow social innovation education programs that position community partners as innovators and train students to support their innovations. This approach moves against the grain of the more common focus on training students to

develop their own innovative solutions and supporting them to launch business start-ups. Two program examples are presented below.

Ideas to Serve competition

Since its inception, SLS has worked closely with The Institute for Leadership and Social Impact (ILSI) in the Scheller College of Business, which, until the advent of SLS, was the only unit on campus focused on teaching social innovation. The partnership has significantly influenced ILSI's Ideas to Serve (I2S) Competition, which supports and rewards student teams innovating around social and environmental challenges. In 2020, ILSI re-conceptualized the competition to reward students for spending more time on problem discovery and definition rather than rushing to articulate a solution.

The evolution of the I2S competition is perhaps most evident in its t-shirt, which evolved from saying, 'What problem will I solve?' to 'What problem will we solve together?' and then to, 'Know what you don't know'. The new version of the competition has two tracks: Problem Discovery (new) and Solution Discovery (old). Both tracks now emphasize the importance of understanding the problem landscape, including existing community-based solutions, and situating new innovations within this landscape.

Two changes have been central to I2S's pivot to focusing on problem discovery. The first is centering community leaders and community entrepreneurs in the discovery process, rather than focusing on the students as the innovators and entrepreneurs; in essence, this can be seen as a switch from positioning students as problem solvers to helping them see themselves as participants in problem-solving, and more specifically, as supporters of solutions being proposed – and in some cases, carried out – by entrepreneurs with deep knowledge of their communities. The second change is providing students with tools to tackle challenges associated with wicked problems. For example, I2S's training workshop, 'Iceberg Models', deals with interdependencies and sociocultural dynamics that often go unseen, while workshops on stakeholder power and mapping teach students to identify stakeholders, including people and organizations; understand how they are connected; and develop skills for addressing conflicting values.

Previously the competition attracted students creating technological solutions for specific problems, usually in the developing world. Now, most entries focus on problem discovery and address challenges in the Atlanta area and the U.S. South. For example, two teams supported the social ventures Carrie's Closet and WUNDERGrubs in problem discovery related, respectively, to advocating for Georgia foster children's rights to resources and supporting digital literacy among Alabama and Mississippi farming cooperatives to improve their crop yield. In keeping with SLS's model of shepherding partners through multiple programs, the entrepreneurs who founded these ventures had already been assisted by multiple students through two SLS programs before they worked with student teams in a social impact course in the Scheller College of Business to prepare I2S entries.

The other program on campus that demonstrates the same approach to social innovation as I2S is SLS's Sustainable Communities Internship Program. This program's animating themes – in both the internship projects and the accompanying internship seminar program – are social innovation, equity, and the United Nations Sustainable Development Goals. Framing all internship partners as community-based innovators, students are invited to work alongside those innovators on their initiatives at the intersection of social equity

and sustainability, exemplified by local innovations in areas such as food systems, energy equity, educational justice, and environmental education.

Sustainable Communities Summer Internship Program

Launched in 2018, the Sustainable Communities Internship Program provides students with 12 weeks of practical experience in supporting solutions for sustainable communities, by pairing them with community partners in Atlanta and across Georgia who need project support. While interning, students also participate in an internship seminar, 'Innovating for Social Impact', which is coordinated by SLS faculty and facilitated by Georgia Tech colleagues and SLS community partners with expertise in sustainability, community engagement, and innovation. Through a partnership with the Career Center, the seminar also provides students with career training and helps them use the internship experience to think critically about their lives, career interests, and goals.

With a three-pronged theme – equity, social innovation, and the United Nations Sustainable Development Goals (SDGs) – the seminar program is the key way for students to experience extended peer communities, learn about other organizations in their field, and connect the seemingly abstract SDGs to concrete work that community organizations are undertaking every day. In their bi-weekly small group seminar meetings students were able to draw connections across seemingly disparate projects – from a Foster Child Bill of Rights, to a Sea Level Sensor Initiative, to a virtual fresh food access map – to see how the specific, local innovations of community organizations and municipal partners contribute to SDGs focused on poverty, health, and climate and do so with an emphasis on equity. Exposure to these projects provides a foundation for students to identify the many forms of expertise that flourish outside of research institutions and to be a part of work undertaken in a rich, multi-stakeholder context – like the eclectic team of K12 educators, scientists, community activists and local leaders who compose the Sea Level Sensor team. The opportunity for an industrial and systems engineering major to apply her data analysis and logistics skills to the creation of an equity evaluator tool for transit-oriented development is a chance for her to see how her technical skills, activated by the knowledge and visions of community members, can support meaningfully positive change in the lives of residents. Given the chance to reflect on their internships with peers in the program, and to learn from local community leaders, academics, and policy makers, turns a summer job into a catalyzing experience, orienting students toward the urgent need to foreground community member perspectives, expertise, and innovations in facing this society's sustainability and equity challenges.

Over four summers, the program has grown by 400%, from 15 to 76 students, and is positioned to increase the student stipend from \$5,000 to \$6,000 and increase the number of total interns to nearly 90 in its fifth summer. SLS has focused on cultivating collaborations within the Institute, with units that share the dual goals of embracing the gifts of partners as co-educators and mentors for students, while also building the organizational capacity of those community partners through the work and energy of students. For example, partner units inside Georgia Tech share the cost of the outside educator who supports curriculum development for the seminar program, and a major contribution from one of Georgia Tech's interdisciplinary research institutes is helping to keep the program completely free for all participating community partners. Although the program comprises mostly Georgia Tech students, Georgia Tech leadership of multi-stakeholder regional networks in sustainability has led to the inclusion of a cohort of students from 10 other institutions around the region.

The ultimate vision is of a program that is co-owned by units across Georgia Tech and can both provide students with critical experiential learning as well as influence Georgia Tech's engineering curriculum overall. The most recent programmatic innovation has been to engage the theme of public interest technology – through both external and internal grant funding – to bring together community partners, engineering faculty, and engineering undergraduate students to craft creative ways to integrate community engagement and public interest (social impact) projects into the engineering curriculum. For example, internal funding has provided means to bring together faculty in Georgia Tech's Writing and Communication Program with engineering faculty and several key community partners to co-create syllabi for PIT-themed first year composition courses that highlight engineering problem solving through melding humanities and STEM content in community-based public interest technology projects. Additionally, the program will give community partners and a multi-disciplinary team of engineering faculty structured time to better understand each other's work, thereby seeding collaborations that can influence the core curriculum in four schools of engineering at Georgia Tech.

Assessing the impact of SLS's educational programs

Chupp and Joseph argue that service learning should seek to impact three groups: students, the academic institution, and the community.³⁵ In this section, we share the results of SLS's assessment activities to date regarding how SLS's integration of sustainability and partner engagement into student learning experiences has impacted each group.³⁶

Student impact

To assess student learning, SLS worked with assessment experts from units across campus to establish the following four Student Learning Outcomes (SLOs) – three of which are related to communities:

- (1) Students will be able to identify relationships among ecological, social, and economic dimensions of sustainability;
- (2) Students will be able to demonstrate skills needed to work effectively in different types of communities;
- (3) Students will be able to evaluate how decisions impact the sustainability of communities;
- (4) Students will be able to describe how they can use their discipline to make communities more sustainable.

These SLOs reflect SLS's attempt to introduce new approaches to problem solving into engineering and technology-focused education. To help students achieve these outcomes, faculty and programs such as those described in earlier sections of this article introduced students to the complexity of problems when understood within broader contexts. They did this via activities such as stakeholder analysis and community partnerships that enabled them to engage collaboratively with multiple stakeholders to apply what they were learning to projects aimed at improving the environmental and social conditions of diverse communities across Atlanta and Georgia.

Two direct assessment approaches were used to measure student performance on these outcomes: pre–post concept maps and scoring of student artifacts. For the first assessment approach, SLS collected 134 paired concept maps from 10 SLS-affiliated courses across a variety of majors, representing 65% of students enrolled in those courses. The Wilcoxon Signed Ranks Test showed a statistically significant increase in the number of concepts between the pre- ($M = 16.97$) and post- ($M = 23.28$) maps ($p < 0.05$). Structural analyses revealed an 82% increase in knowledge breadth: 51% in depth; and 43% in connectedness, with statistically significant increases. These results demonstrate evidence of students' knowledge expansion regarding the challenge of understanding and engaging multivalent, wicked problems.

These results were demonstrated on a micro-level in a concept map study conducted in one SLS-affiliated upper-level ecology course. Based on concept map analysis, faculty members Pruett and Weigel reported 'increases in sustainability knowledge breadth, depth, and complexity, particularly in demonstrating biological-sociological connections',³⁷ specifically due to a two-week applied learning project on water quality. The study concludes that even a short-term real-world project can have significant impact on student learning.

For the second assessment approach, faculty members identified one or two learning outcomes that aligned with their affiliated courses. SLS then worked with a group of faculty and staff to jointly develop a rubric for each outcome, structured to assess student performance on a continuum of *Beginning*, *Developing*, *Competent*, and *Accomplished*. Finally, SLS worked with Georgia Tech's Office of Academic Effectiveness to recruit faculty and staff to participate in scoring students' artifacts based on the rubrics.

The results of that assessment process indicate overall that, across all four outcomes, the majority of artifacts scored at *Developing* or *Competent* – meeting the target outcome, and over 50% of artifacts scored at *Competent* or *Accomplished* in six dimensions: recognizing the three dimensions of sustainability; communication; observation; explanation of issues and context; connections to one's discipline; and self-assessment and reflection. Students scored particularly well in recognizing sustainability's three dimensions and understanding social context, suggesting that students are adept at explaining issues in terms of frameworks embracing social, environmental, and economic dimensions of sustainability and are able to connect that three-pronged approach to their own experiences. Relatedly, students demonstrated awareness that one's own experiences impact one's understanding of context and of proposed solutions to sustainability problems in communities.

Overall, assessment of concept maps and student artifacts from SLS-affiliated courses demonstrated how incorporating community partnerships and service-learning impacts student learning, in relation to both understanding the various dimensions of wicked problems and also learning what it means to form and operate successfully in extended peer communities, including relating to community members as experts.

Indirect assessment has also demonstrated the value of applied learning projects with community partners in helping students at a STEM institution think in new ways. Results from the yearly Georgia Tech Exit Survey provide some insight into impact on student learning. The exit survey asks undergraduate students, 'to what extent did your Georgia Tech education contribute to your knowledge, skills, and personal growth in development of an appreciation for different cultures', 'ability to work with individuals from diverse backgrounds', and 'understanding the role of your discipline in solving global problems?' SLS students ($n = 927$; $n = 926$; $n = 960$) rated themselves higher ($M = 3.38$; $M = 3.28$;

M = 3.40) than students who did not participate in SLS courses (M = 3.08; M = 2.92; M = 3.33) in 2020. While we cannot claim a causal effect, these results suggest that students enrolled in SLS courses and programs gained confidence in their ability to work in diverse cultures and a greater understanding of their roles in solving wicked global problems as they manifest locally.

Reflections submitted by internship program students from multiple years have also shed light on how this program in particular influences students' understandings of partner expertise and equity in areas such as community-based project work, understanding community history and context, and drawing on their experiences collaborating with communities as they shape their careers. For example, a student who participated in the program in 2018 reflected that networking with partners during her internship helped her understand the importance of 'sense of place' and how a community's values and beliefs make sustainability work for that specific community – in essence expressing an understanding of the key role of working through extended peer communities, with community professionals, to figure out how to address wicked problems at the local level. She wrote, 'I learned a lot about what works best and what doesn't when developing partnerships, lessons I can apply throughout my life as I work to develop sustainable projects and partnerships'. Another student from 2020, who had also participated in other SLS programs, wrote:

Participating in SLS programming completely changed my trajectory. The lessons I've learned and the connections I made through these programs have given me the opportunity to find meaningful full-time work in the social impact sector. SLS was also instrumental in helping me build the perspective necessary to engage in this work in a way that is uplifting and deeply respectful of the subject matter expertise of those already engaged.

Institutional impact

As stated above, our formal assessment program to date has focused on individual student learning outcomes. While the impact of applied learning and service learning on students is well-researched, its impact on institutions and communities is assessed far less often. However, three pieces of evidence indicate that SLS's community engagement and equity interventions have had a significant impact on Georgia Tech as an institution.

The first relates to student engagement and learning and comes from the results of the National Survey of Student Engagement (NSSE), comparing 2017 and 2020 data. Table 1 shows that students enrolled in SLS courses attended significantly more events that address important social, economic, or political issues than non-SLS students.

Table 1. NSSE results-events.

	2017		2020	
Attending events that address important social, economic, or political issues (four-point scale)	SLS students (n = 272)	Non-SLS students (n = 1,030)	SLS students (n = 602)	Non-SLS students (n = 500)
	M = 2.46** SD = 0.85	M = 2.19 SD = 0.88	M = 2.62* SD = 0.87	M = 2.49 SD = 0.86

Note: * $p < 0.05$, ** $p < 0.01$. A two-sample t-test was applied to compare percentage differences between SLS and non-SLS groups. Acronyms: NSSE, National Survey of Student Engagement; SLS, Serve Learn Sustain.

Table 2. NSSE results in 2014, 2017 and 2020

NSSE Items	2014 (baseline)		2017		2020	
	Georgia Tech	AAU	Georgia Tech	AAU	Georgia Tech	AAU
Total Respondents	FY n = 421 SR n = 611		FY n = 535 SR n = 763		FY n = 416 SR n = 686	
Service Learning FY	32%	43%	41%**	43%	48%*	41%
SR	37%	46%	41%	47%	50%**	48%
Internship/Field Exp. SR	72%	60%	76%	58%	78%*	57%

* $p < 0.05$, ** $p < 0.01$. A two-sample t-test was applied to compare baseline and other years' percentage differences. Acronyms and abbreviations: NSSE, National Survey of Student Engagement; AAU, Association of American Universities; FY, first-year students; SR, senior students.

NSSE survey results also reveal a significant increase in student participation in service learning experiences.

The Service Learning and Internship or Field Experience items among first-year (FY) students and senior (SR) students were identified as key benchmark questions reflecting our SLS goals. Baseline values from 2014 were used as a pre-SLS baseline. Table 2 shows a significant increase in the number of students participating in these experiences during the SLS years. Results also demonstrate that service learning participation has now surpassed that of the Association of American Universities (AAU) cohort.

The second piece of evidence of institutional impact relates to impact on faculty members' research. While the primary focus of SLS has been undergraduate education, our approach to engaging faculty members included supporting them in building extended peer research communities and incorporating a central focus on equity into sustainability-related research projects. As a result, SLS is now regularly sought out by faculty members and research centers to support and participate in major research projects. Over the last three years, faculty engagement with SLS has led to at least seven major sustainability research initiatives or proposals led by faculty members in engineering and science that have a deep focus on equity and community. Additionally, in 2022, Georgia Tech's executive leadership provided funding to the sustainability research institute on campus to hire a community-engaged research specialist – the first position of its kind.

This third piece of evidence of institutional impact is Georgia Tech's new strategic plan for 2020-2030,³⁸ which prioritizes sustainability, the UN SDGs, service learning, community partnerships, and equity. While there are a number of units and initiatives across campus that laid the groundwork for the university to prioritize these issues, SLS has been an out-front and vocal leader in these areas over the past seven years. For example, a search on the Georgia Tech website for 'structural racism' reveals that SLS was a forerunner in educating students and the campus on this concept, beginning with an event series that it sponsored on the topic in 2016. Additionally, through its role as co-founder of the Regional Centre of Expertise (RCE) Greater Atlanta network, SLS became the first unit to actively engage stakeholders from across campus in collaboratively advancing the UN SDGs as a framework for teaching and researching wicked problems. Building on this work, SLS staff played active and lead roles in the collaborative Georgia Tech strategic planning process in 2020. In recognition of its impact, a plan is being put in place to restructure SLS to work more closely with multiple units on programs that center equity as key to sustainability and that link teaching, research, operations, and community partnerships.

Community impact

Tryon and Stoecker argue that the impact of service learning and partnerships with universities on community partners and communities themselves has been severely under-researched.³⁹ While SLS has not yet formally assessed the impact of its work on community partners and communities, from the beginning SLS established a Partnership Advisory Council as a formal mechanism for collaborating with and receiving regular input from partners. With input from council members, SLS established partnership guidelines that make clear that SLS honors partners as collaborators through both materially compensating and philosophically privileging them and their experiences. Our guidelines are expressed through the SLS Partnership Strategy and our Service Learning and Community Engagement Toolkit, both available online as open-access resources. Council members provided feedback on everything from our stipend and honoraria guidelines to how SLS should determine which types of communities to prioritize as partners, given the history of racism and inequity in the Atlanta region.

Anecdotal data from our close partners in regular reflection meetings suggests that they are having both positive experiences and some challenges in the courses and programs with which they are engaged. Partners highlight the capacity building that our internship program supports; the eager co-learning disposition of students (rather than a “service-delivery” orientation); and the availability of course partnerships that complement partner assets with STEM students’ technical skills. Challenges partners frequently cite include the slowness of the institution to process payments; the rigidity of the semester timeline; and the lack of easy-to-access meeting space on the Georgia Tech campus – challenges we are striving to address through new opportunities such as SLS’s Partner in Residence program. Through this program, the partner is accorded a more substantial honorarium and “affiliate” status, making the partner a university employee with access to campus resources and facilities. However, beyond anecdotal testimony from community-based organizations and optimism from our inaugural partners in residence, we have almost no evidence of how our work is impacting community members. To remedy this issue moving forward, SLS has taken the lead, together with Georgia Tech’s external relations office, in proposing that Georgia Tech establish a university-wide community impact program guided by a community benefits framework such as the Democracy Collaborative’s Anchor Institution Community Benefit Dashboard,⁴⁰ which includes metrics in economic development, community building, K-12 education, and health, safety, and environment, and with local indicators co-designed by the university and partners from surrounding communities. Our proposal for establishing metrics and assessing impact includes developing engaged teaching and research metrics, to further push institutional change to value not just student impact, but also impact on communities that work with us – which of course in turn increases and improves impact on students.

Overall impact

In sum, our assessment data to date on individual-level student learning suggest that our affiliated courses and co-curricular programs are having some success helping students both to recognize community partners as experts and collaborators rather than clients and to see equity and justice as key components of sustainability. On the institutional level,

it is clear that SLS has had a significant impact on student interest and engagement in service learning and social issues, on Georgia Tech's academic and research culture, and on the university's priorities regarding community engagement.

However, our assessment program has been limited in three ways. First, most of our focus has been on assessing student learning over the course of single courses taught for one semester. Second, all our formal assessment has focused on assessing courses, while assessment of curricular *programs* (as opposed to courses), such as the Sustainable Cities Minor that SLS co-runs, as well as of co-curricular programs, such as the Ideas to Serve Competition and the Internship Program, has been sporadic, inconsistent, limited, and focused solely on indirect assessment (e.g. reflections and surveys measuring only self-perception). Third, SLS has conducted no significant assessment of the impact of our activities on partners' work and communities.

Our goal moving forward, as evidenced by the discussion above about establishing community impact metrics, is to switch our emphasis from single semester student learning assessment to assessment of long-term impact – on student learning and career paths, faculty teaching and research (e.g. development of competency for partnering with communities to conduct action research), and partners (capacity-building and community impact). To do this, SLS is exploring abandoning the SLOs to focus instead on SDG competencies, such as UNESCO's cross-cutting competencies for achieving the SDGs,⁴¹ which is one of the competency frameworks referenced in the sustainability education report released in 2020 by the National Academies of Sciences, Engineering, and Medicine.⁴² Aligning with these competencies would allow us to continue to improve our program for assessing student impact by learning from and contributing to the growing sustainability competencies field. Additionally, since these competencies are targeted at action – at reorienting education so that it equips students to, for example, enter careers in which they can advance the Sustainable Development Goals – moving in this direction would help push Georgia Tech to better deliver on its impact-oriented strategic plan.

Adjusting assessment in these ways – with a special emphasis on expanding and centering assessment of the community impact of university-community partnerships – is key to determining the ways in which, and the extent to which, establishing applied learning experiences that operate via the principles of extended peer communities may be able to tackle wicked problems in effective ways and also teach new generations of leaders how to incorporate these approaches into their civic lives in the future.

Conclusion

This article has explored how Georgia Tech's Center for Serve-Learn-Sustain strives to better prepare engineering and technology-focused students to use their knowledge and skills to advance sustainable development by collaborating with community partners as experts, innovators, and co-educators. Through a discussion of two key community partnerships, we described engaging in intentional relationship development that allows for growth and change, using an asset-based approach to our work with partners as community professionals, and making a commitment to equity as a core part of the principles and practice of each partnership. In describing our social innovation programs, we underscored the ways that positioning partners as experts and innovators shifts how students interact with communities and understand the role of their own skills in advancing community

visions for change. Finally, by outlining the educational impacts of these programs – and recognizing the places where a lack of community impact data and the challenges of assessing that kind of impact accurately necessitate new frameworks – we suggested that students can and do respond profoundly to the opportunities to stretch themselves, their thinking, and their aspirations, especially when it comes to putting their skills into action to create a more sustainable and just society.

While it may seem difficult to consider making radical changes to our educational processes while we are all, personally and institutionally, struggling with the ‘twin pandemics’ of COVID-19 and racial injustice, this may in fact be the perfect time to do so. If we take our cues from the students, we will likely find that they are ready and eager to engage in education that better prepares them to create change. One student who participated in an SLS short course on social innovation commented that engaging in collaborative learning and problem solving alongside not only other students, but also community partners, staff, and faculty, relieved her of the burden of feeling that she alone is responsible for identifying solutions. It freed her, she told us, to think more broadly and experiment more creatively. Perhaps, then, the immobilizing pressure to single-handedly ‘solve’ our greatest sustainability challenges might be displaced by the excitement of working with others in an extended and eclectic peer network animated by a shared commitment to equity and justice.

Notes

1. Rittel and Webber, “Dilemmas in a General Theory.”
2. National Academies of Sciences, Engineering, and Medicine, *Environmental Engineering*.
3. National Academies of Sciences, Engineering, and Medicine, *Strengthening Sustainability Programs*.
4. Tabulawa, “Interdisciplinarity, Neoliberalism and Academic Identities,” 13.
5. Bilge, “Intersectionality Undone,” 407; Smele et al, “Doing Feminist Difference Differently” 1, 3.
6. Smele et al, 3.
7. “ReGenesis Case Study.”
8. Shove and Walker, “CAUTION! Transitions Ahead.”
9. Funtowicz and Ravetz, “Environmental Problems.”
10. *Ibid.*, 753.
11. Verrax, “Engineering Ethics,” 77.
12. Lucena et al., *Engineering and Sustainable Community Development*, 9.
13. *Ibid.*, 135.
14. Downey, “What is Engineering Studies For?,” 70, 57.
15. Ottinger, “Rupturing Engineering Education,” 245-246.
16. Cohen and Ottinger, “Introduction: Environmental Justice,” 2-3.
17. Georgia Institute of Technology, Assessment of the Quality Enhancement Plan.
18. SLS, “QEP,” 10.
19. Lucena, Schneider, and Leydens, *Engineering and Sustainable Community Development*; Rodney, *How Europe Underdeveloped Africa*; Mies, “The Myth of Catching-Up Development.”
20. Agyeman et al, *Just Sustainabilities*.
21. See Mitchell, “Critical Service-Learning”; and Stoecker, *Liberating Service Learning*.
22. Lima and Oakes, *Service Learning: Engineering in Your Community*, 199, 199.
23. *Ibid.*, 194.
24. Lima, “The LSU Playground Project,” 504.
25. *Ibid.*, 47.
26. Kretzman and McKnight, *Building Communities*; “ABCD Institute Resources.”

27. Smith, *Social Innovation, Democracy, and Maker Spaces*, 2.
28. For example, see Dorado and Giles, "Serving-Learning Partnerships" and Chupp et al., "Toward Authentic University-Community Engagement."
29. Ottinger, "Rupturing Engineering Education."
30. Lucena et al., *Engineering and Sustainable Community Development*, 92.
31. Ravel et al., "Evolving Engineering Education."
32. To learn more about SLS's partnership approach, see the SLS Partnership Strategy.
33. See WAWA webpage: <https://www.wawa-online.org/>
34. See Groundwork Atlanta webpage: <http://www.groundworkatlanta.org/>
35. Chupp and Joseph, "Getting the Most Out."
36. Much of the assessment data included here comes from the QEP Impact Report submitted by Georgia Tech to the Southern Association of Colleges and Schools Commission on Colleges (SACSCOC) in March 2021.
37. Pruet and Weigel, "Concept Map Assessment," 1.
38. Georgia Institute of Technology, Strategic Plan.
39. Tryon and Stoecker, "The Unheard Voices."
40. The Democracy Collaborative, Anchor Dashboard.
41. UNESCO, Education for Sustainable Development.
42. National Academies of Sciences, Engineering, and Medicine, Strengthening Sustainability Programs.

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References

- Agyeman, Julian, Robert D. Bullard, and Bob Evans, eds. *Just Sustainabilities: Development in an Unequal World*. Cambridge: MIT Press, 2003.
- Allen, Jennifer H., Fletcher Beaudoin, and Beth Gilden. "Building Powerful Partnerships: Lessons from Portland's Climate Action Collaborative." *Sustainability: The Journal of Record* 5, no. 10 (2017): 276–281. <https://doi.org/10.1089/sus.2017.0010>.
- Beaudoin, Fletcher, and Katya Brundiers. "A Guide for Applied Sustainability Learning Projects." AASHE, 2017. https://hub-media.aashe.org/uploads/A+Guide+for+Applied+Sustainability+Learning+Projects_v1.0_03.03.17_Final.pdf.
- Bilge, Sirma. "Intersectionality Undone: Saving Intersectionality from Feminist Intersectionality Studies." *Du Bois Review* 10, no. 2 (2013): 405–424. doi:10.1017/051742058X13000283.
- Birney, Anna, Joshua Cubista, Dori Papi-Thornton, and Laura Winn. *Systems Change Education in an Innovation Context*, 2019. https://issuu.com/tacklingheropreneurship/docs/systems-change-education-report_da.
- Brundiers, Katya, Arnim Wiek, and Charles Redman. "Real-world Learning Opportunities in Sustainability: from Classroom into the Real World." *International Journal of Sustainability in Higher Education* 11, no. 4 (2010): 308–324. <https://doi.org/10.1108/14676371011077540>.
- Chupp, Mark G., Adrienne M. Fletcher, and James P. Gaulty. "Toward Authentic University-Community Engagement." *Journal of Community Practice* 20, no. 4 (2021): 435–449. <https://doi.org/10.1080/10705422.2021.1992556>.
- Chupp, Mark G., and Mark L. Joseph. "Getting the Most Out of Service Learning: Maximizing Student, University and Community Impact." *Journal of Community Practice* 18, no. 2-3 (2010): 190–212. <https://doi.org/10.1080/10705422.2010.487045>.
- Cohen, Benjamin R., and Gwen Ottinger. "Introduction: Environmental Justice and the Transformation of Science and Engineering." In *Technoscience and Environmental Justice: Expert Cultures in a Grass-roots Movement*, edited by Gwen Ottinger, and Benjamin R. Cohen, 1–18. Cambridge, MA: MIT Press, 2011. <https://doi.org/10.7551/mitpress/9780262015790.003.0010>

- The Democracy Collaborative. *Anchor Dashboard Learning Cohort*. The Democracy Collaborative, 2013. <https://community-wealth.org/indicators#measure>.
- Diers, Jim. *Neighbor Power: Building Community the Seattle Way*. Seattle: University of Washington Press, 2004.
- Dorado, Silvia, and Dwight E. Giles, Jr. "Service-Learning Partnerships: Paths of Engagement." *Michigan Journal of Community Service Learning* 1, no. 11 (2004): 25–37.
- Downey, Gary Lee. "What is engineering studies for? Dominant Practices and Scalable Scholarship." *Engineering Studies* 1, no. 1 (2009): 55–76. <https://doi.org/10.1080/19378620902786499>.
- Funtowicz, Silvia, and Jerome Ravetz. "Environmental Problems, Post-normal Science, and Extended Peer Communities." *Etudes et Recherches sur les Systèmes Agraires et le Développement*, INRA, (1997): 169–175. <https://hal.archives-ouvertes.fr/hal-01231607>.
- Georgia Institute of Technology. *The Georgia Tech Strategic Plan: The Next 10 Years*. Georgia Institute of Technology, 2020. <https://strategicplan.gatech.edu/sites/default/files/georgia-tech-strategic-plan-2020-2030.pdf>.
- Georgia Institute of Technology. *Assessment of the Quality Enhancement Plan*. In *Report of the Affirmation Committee, Georgia Institute of Technology*, Southern Association of Colleges and Schools Commission on Colleges, 2021.
- Hirsch, Jennifer, Abigail Lewis, Ryan Lugalía-Hollon, Lisa Kim, Sarah Sommers, and Alexis Winter. "Our Climate, Our Change: Using Visual and Interactive Practices to Expand Participation and Leadership in Climate Action." In *Emergent Possibilities for Global Sustainability: Intersections of Race, Class and Gender*, edited by Denise Torres, and Phoebe Godfrey, 234–246. Abingdon: Routledge, 2016.
- Kretzman, John P., and John McKnight. *Building Communities from the Inside Out: A Path Toward Finding and Mobilizing a Community's Assets*. Chicago: ACTA, 1993.
- Lima, Mary Beth. "The LSU Community Playground Project: Reflections on 16 Years of an Engineering Service-Learning Program." *International Journal for Service Learning in Engineering* Special Issue (2014): 492–508. <https://doi.org/10.24908/ijlse.v0i0.5565>.
- Lima, Mary Beth, and William Oakes. *Service Learning: Engineering in Your Community*. Wildwood, MO: Great Lakes Press, 2006.
- Lucena, John, Jen Schneider, and Jon A. Leydens. *Engineering and Sustainable Community Development*. Williston, VT: Morgan & Claypool Publishers, 2010.
- Mies, Maria. "The Myth of Catching-Up Development." In *Ecofeminism*, edited by Maria Mies, and Vandana Shiva, 55–69. London: Zed Books, 1993.
- Mitchell, Tania D. "Traditional vs. Critical Service-Learning: Engaging the Literature to Differentiate Two Models." *Michigan Journal of Community Service Learning* 2, no. 14 (2008): 50–65.
- Mitchell, Tania D. "Critical Service-Learning as a Philosophy for Deepening Community Engagement." In *Deepening Community Engagement in Higher Education. Community Engagement in Higher Education*, edited by Ariane Hoy, and Mathew Johnson, 263–269. London: Palgrave Macmillan, 2013. https://doi.org/10.1057/9781137315984_20
- National Academies of Sciences, Engineering, and Medicine. *Environmental Engineering for the 21st Century: Addressing Grand Challenges*. The National Academies Press, 2019.
- National Academies of Sciences, Engineering, and Medicine. *Strengthening Sustainability Programs and Curricula at the Undergraduate and Graduate Levels*. The National Academies Press, 2020.
- Ottinger, Gwen. "Rupturing Engineering Education: Opportunities for Transforming Expert Identities through Community-Based Projects." In *Technoscience and Environmental Justice: Expert Cultures in a Grassroots Movement*, edited by Gwen Ottinger, and Benjamin R. Cohen, 229–248. Cambridge, MA: MIT Press, 2011. <https://doi.org/10.7551/mitpress/9780262015790.003.0010>
- Pruett, Jessica L., and Emily G. Weigel. "Concept Map Assessment Reveals Short-Term Community-Engaged Fieldwork Enhances Sustainability Knowledge." *CBE - Life Sciences Education* 3, no. 19 (2020): 1–10. <https://doi.org/10.1187/cbe.20-02-0031>.
- Ravel, Mihir K., Benjamin Linder, William Oakes, and Carla B. Zoltowski. "Evolving Engineering Education for Social Innovation and Humanitarian Impact - Lessons Learned Across a Range of Models." In *2015 IEEE Global Humanitarian Technology Conference (GHTC)*, 169–176. Institute of Electrical and Electronics Engineers, 2015. <https://doi.org/10.1109/GHTC.2015.7343969>

- ReGenesis Case Study: Chemical Safety and Ethics in Relation to Communities," Serve-Learn-Sustain Teaching Toolkit, <https://serve-learn-sustain.gatech.edu/regenesis-case-study-chemical-safety-ethics-relation-communities>
- Rittel, Horst W. J., and Melvin M. Webber. "Dilemmas in a General Theory of Planning." *Policy Sciences* 4 (1973): 155–169. <https://doi.org/10.1007/BF01405730>.
- Rodney, Walter. *How Europe Underdeveloped Africa*. London: Bogle-L'Ouverture Publications, 1972.
- Serve-Learn-Sustain Partnership Strategy. https://serve-learn-sustain.gatech.edu/sites/default/files/documents/2022_partnership_strategy.pdf.
- Shove, Elizabeth, and Gordon Walker. "Caution! Transitions Ahead: Politics, Practice, and Sustainable Transition Management." *Environment and Planning A: Economy and Space* 39, no. 4 (2007): 763–770. doi:10.1068/a39310.
- Smele, Sandra, Rehanna Siew-Sarju, Elena Chou, Patricia Breton, and Nicole Bernhardt. "Doing Feminist Difference Differently: Intersectional Pedagogical Practices in the Context of the Neoliberal Diversity Regime." *Teaching in Higher Education* (2017): 1–15. doi: 10.1080/13562517.2016.1273214.
- Smith, Adrian. *Social Innovation, Democracy, and Maker Spaces*. SPRU Working Paper Series, Science Policy Research Unit, University of Sussex Business School, 2017.
- Stoecker, Ryan. *Liberating Service Learning and the Rest of Higher Education Civic Engagement*. Philadelphia: Temple University Press, 2016.
- Tabulawa, Richard. "Interdisciplinarity, Neoliberalism and Academic Identities: Reflections on Recent Developments at the University of Botswana." *Journal of Education: University of KwaZulu-Natal* 69 (2017): 11–42.
- Tryon, Elizabeth, and Ryan Stoecker. "The Unheard Voices: Community Organizations and Service Learning." *Journal of Higher Education Outreach and Engagement* 3, no. 12 (2008): 47–59.
- UNESCO. *Education for Sustainable Development Goals: Learning Objectives*. UNESCO, 2017. https://www.unesco.at/fileadmin/Redaktion/Publikationen/Publikations-Dokumente/2017_Education_for_SDG.pdf, 2017.
- Verrax, Fanny. "Engineering Ethics and Post-Normal Science: A French Perspective." *Futures* 91 (2017): 76–69. <https://doi.org/10.1016/j.futures.2017.01.009>.
- Zint, Michaela, and Kimberly S. Wolske. "From Information Provision to Participatory Deliberation: Engaging Residents in the Transition toward Sustainable Cities." In *Elgar Companion to Sustainable Cities*, edited by Daniel Mazmanian, and Hilda Blanco, 188–209. Cheltenham: Edward Elgar Publishing, 2014.