

UIC Summer Institute on Sustainability and Energy: A Case Study for an Interdisciplinary Collaborative Approach

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Abstract—The Summer Institute on Sustainability and Energy (SISE) at the University of Illinois at Chicago (UIC) introduces a multi-method, interdisciplinary sustainability education framework. Spanning national laboratories, academia, and industry, the SISE program embraces best practices and essential components of sustainability education through lecture series, panel discussions, mentoring, networking, site visits and collaborative research projects. Of particular importance are the interdisciplinary research teams, tasked with developing creative, innovative solutions to real world energy and sustainability challenges that address policy, science and technology, and entrepreneurship, and proposing an innovation that spans across these foundational disciplines. One collaborative team and their innovative research project from SISE 2013 are presented as a case study for sustainability education through an interdisciplinary lens.

Keywords

Sustainability education
Interdisciplinary teaching methods
Collaborative learning
Energy and sustainability

I. INTRODUCTION

The impact of climate change destabilization in the 21st century poses complex environmental, technological, health, safety, and economic threats to the security and well being of the U.S. and global community. Neighborhoods, communities, cities and regions that incorporate diverse sustainable initiatives are better prepared to mitigate future challenges and get closer to building resiliency to environmental, economic, and societal risks from climate change (Orr, 2011). Current and future decision makers leading sustainability initiatives across political, economic, social, and environmental boundaries can launch the U.S. and the world toward more effective and innovative approaches that address climate change issues. Education remains a critical component to supporting sustainable development strategies. Extending best sustainability educational practices can encourage and equip the next generation to address the global challenges that result from climate change.

From the discovery of new materials and phenomena to the innovation of new technologies, the proactive stewardship of the environment and the transition from reliance on fossil fuels to renewables, sustainable practices and sustainability education are

significantly influencing future development. Traditionally, sustainability education promotes an integrated and holistic conception of the world as well as methodologies to cope with the complexity, uncertainty and contested knowledge that permeate sustainability in general (Wals, 2014). The 2012 Report on the United Nations Decade of Education for Sustainable Development identifies nine types of learning trends for sustainable development education. A survey conducted in 102 countries identified the following five practices that occurred most frequently in programs and seminars focused around sustainability: *Discovery learning, Systems thinking-based learning, Critical thinking-based learning, Interdisciplinary learning, Problem-based learning, and Participatory/collaborative learning* (UNESCO, 2012). The report demonstrated that a single approach model for teaching sustainability is not sufficient. Rather, a combination of multiple and diverse teaching practices is the preferred model.

In the fall of 2010, the Energy Initiative at the University of Illinois at Chicago (UIC) began to develop an intensive, interdisciplinary educational model bringing together STEM (science, technology, engineering, mathematics) fields with sustainability, innovation, business, entrepreneurship, planning, policy, economics, and social sciences to broaden the minds of future decision makers. This model, known as The Summer Institute on Sustainability and Energy (SISE), is the first of its kind in the United States, and seeks to enrich the minds of young individuals across disciplinary boundaries through critical and innovative thinking and collaboration. Now entering its fourth year, over 150 participants have gained knowledge and experience to approach complex sustainability challenges through the interdisciplinary learning methodologies presented by SISE.

Following the shift in teaching approaches from teacher- to learner-centered, SISE embraces a diverse learning structure to cultivate innovative ideas and support sustainability education to its fullest extent. Incorporating a variety of teaching and learning approaches and converging on sustainability education through multi-method, interdisciplinary and collaborative efforts can maximize problem-solving capacity and encourage sustainable development in behavior and practice (Tilbury, 2011). Single disciplinary methodologies insufficiently incorporate the complex, multifaceted and abundant concerns surrounding sustainability challenges (Jones *et al.*, 2010). The SISE program embodies these doctrines for learning sustainability through interdisciplinary collaboration as a catalyst for innovation. Ultimately, SISE takes a multi-methods approach to learning, garnering from best practices in sustainability education. The following sections explore SISE's interdisciplinary and collaborative approach to sustainability and energy education.

II. SISE PROGRAM OBJECTIVES

The mission of SISE is to cultivate the next generation of interdisciplinary and sustainability-minded professionals, researchers, and academics in government, industry, and academia by integrating science and energy technologies with other disciplines. SISE alumni will be these future leaders, well equipped to make educated and sustainable decisions about energy at personal, civic, and global levels. Many U.S. sustainability educational programs tend to focus on critical interdisciplinary aspects of sustainability through didactic in-class lectures. SISE's approach reaches beyond this typical university model, challenging participants to learn, engage, and apply multiple disciplinary perspectives to address real world energy and sustainability challenges, develop innovative research solutions to those challenges, and facilitate sustainable initiatives through interdisciplinary collaboration.

The 2008 Department of Energy (DOE) report, *New Science for a Secure and Sustainable Energy Future*, prepared by the Basic Energy Science Advisory Committee, furnished additional support for the SISE educational framework. The DOE report delineates the scientific opportunities and challenges to achieve energy security, lower CO₂ emissions, reduce reliance on foreign oil and create enduring economic growth through discovery, development and the marketing of new technologies for sustainable energy production, delivery, and use (BESAC, 2008). Paralleling these guiding principles and the previously mentioned UN report recommendations, the UIC Energy Initiative developed SISE as an interdisciplinary model for educating future decision makers on sustainability and energy. This complex framework engages participants from different disciplines in a collaborative, critical and innovative educational process by applying concepts of sustainability to real-

world energy and sustainability challenges reaching beyond traditional classroom instruction.

SISE has four objectives to achieving its educational goal. First, the main purpose of SISE is to increase the number of informed individuals who can engage sustainability and energy challenges. Second, SISE will strengthen the number of collaborative professionals in sustainability and energy related disciplines to be conversant in their respective fields as well as in energy, technology and the sciences. Third, SISE's goal is to expand the number of sustainability and energy professionals entering the workforce. Lastly, SISE encourages and necessitates innovation, giving rise to sustainability-minded professionals, researchers and entrepreneurs applying interdisciplinary thinking to advance energy and sustainability practices and technological advancements.

III. FRAMEWORK AND PROGRAM COMPONENTS

The SISE program is rich with interdisciplinary content and multi-method learning experiences. Each year, SISE has a specific focused theme, and builds a program to support a sustainability educational framework within the context of that theme. In 2013, Sustainable Transportation provided the focus for the SISE program. Over the course of two weeks, participants were exposed to different disciplinary perspectives of transportation and a diversity of experiences in Chicago, where the city became an additional resource for learning.

SISE features four components: lectures, site visits, research, and mentoring. Traditional lectures are followed by interdisciplinary panel discussions, where students engage in deep conversation on specific topics covered during the lecture series that day. Supplementary site visits, ranging from technical laboratories to urban infrastructure to new models of sustainable practices, provide a rich base for participants to experience first hand the workings of existing sustainability and energy projects and programs. The research component highlights the interdisciplinary context of the SISE program, where not only are the teams made up of participants from varied backgrounds and fields of study, but the research challenge project specifically requires students to think beyond their own discipline and find solutions across different areas. The extensive mentoring from professionals, academics, and scientists scheduled strategically during the program contributes to the participants learning experiences through different disciplinary lenses. Tangentially, networking events during the program are crucial for students to learn to engage in conversation about sustainability and energy with well-respected professionals from different fields. Figure 1 represents the different component working together. SISE was created as a way to engage students in multiple learning experiences and to integrate

principles of sustainability in an interdisciplinary framework.



Figure 1: SISE Program Components

This diagram illustrates the different program components working together to support the collaborative research projects each team is designated. Lectures provide teams with a basis of knowledge of sustainability concepts that can be realized in application through site visits. These two components help teams develop ideas and mentoring from experts in different fields refine their preliminary ideas into developed research proposals.

SISE’s framework and program components exemplify an interdisciplinary approach to sustainability education. Students glean from the basic, technical and general sustainability knowledge provided in the lectures, panel discussions, site visits, and mentoring (see Figure 2 below for photos of program components). They utilize these learning exchanges to develop solutions to real-world sustainability and energy challenges. The format of this intensive program demands that students work in groups of students from different disciplines to apply this interdisciplinary knowledge to promote different ways of thinking about complex societal problems we face today.

IV. SISE PARTICIPANTS

SISE’s interdisciplinary framework is reflected in the demographics and interests of the participants. Many are still students (both graduate and undergraduate), and some come from industry looking for ways to expand their knowledge and experience. Their backgrounds or areas of study/interest vary greatly, with many coming from the hard sciences and engineering, as well as the social sciences, business, policy, economics, and other disciplines. Ultimately, SISE participants already bring a multi-disciplinary perspective to the program that is critical to the interdisciplinary framework of SISE.



Figure 2: SISE Lecture Series/Panel Discussion and Mentoring Session

One hundred forty individuals applied to the SISE 2013 and fifty-four were selected and admitted to the program. Participants came from over 15 different states. Of the 53 participants, 28 were male (53%) and 25 were female (47%). The self-identified race/ethnicity background of the participants was: White 29 (55%), 17 (32%) Asian, 3(6%) Black, 3 (6%) Hispanic, 3 (6%) Middle Eastern, and 1(2%) Western European. Most of the participants fit in the youngest age group, 18-25 (55%), followed by 19 participants (36%) between 26 and 35, 4 (8%) between 36 and 45, and 1 participant (2%) between 46 and 55 years of age. Nineteen participants were students in a master’s level program (36%), 12 (23%) were in doctoral level programs, and 12 (23%) were enrolled in undergraduate programs (see Figure 3). Additionally, there was one participant who was a post-doctoral candidate, and 9 (17%) who were not enrolled in school. Figure 4 below illustrates the different backgrounds of the 2013 participants. Although the engineering makes up nearly 37%, there were eight different engineering fields represented by the participants.

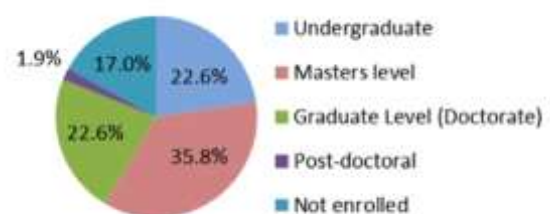


Figure 3: Participant Academic Standing

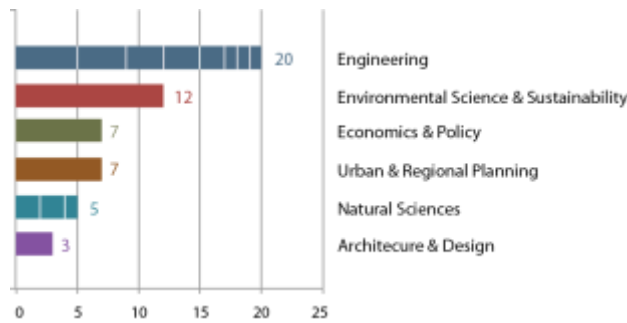


Figure 4: SISE Participant Backgrounds

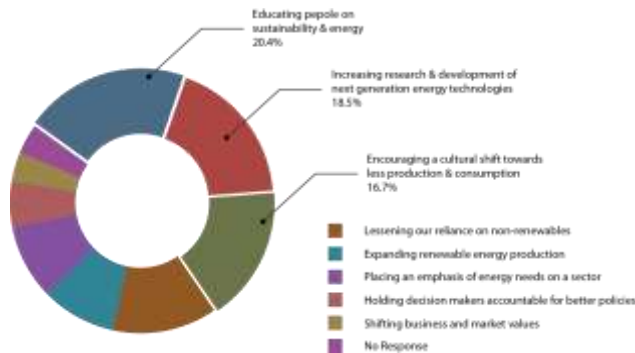


Figure 5: Responses to the Importance of Future Energy and Sustainability Related Challenges

Participants were asked to rank the importance of several energy and sustainability-related challenges from one to eight, with one being most important and eight being least important. The challenges most frequently ranked as most important (ranking of 1) were educating people on energy and sustainability (20.4%) and increasing research and development of next generation energy technology (18.5%), as seen in Figure 5 below.

V. 2013 CASE STUDY: TEAM RESEARCH PROJECT

Background

Each year the SISE program formulates four research projects illustrating the focus of the program year (sustainable transportation) as well as representing broader energy and sustainability themes. On the whole, the goal of these research projects is to engage participants in the interdisciplinary nature of energy through real-world projects.

A committee composed of partner programs and SISE alumni prepare the research projects annually. Participants receive scholarly resources from various disciplines a month before the program to introduce diverse energy issues, encourage critical analysis of the subject areas, and spark creative thinking. Some resources are broad in nature, meant to provide overviews of different fields and applicable to all SISE programs and projects, while other resources are more specific to reflect the projects and the theme for that particular program year.

On the second day of SISE, participants are assigned to their research teams, which are carefully arranged to capitalize on the interdisciplinary backgrounds of the participant population. No two participants will have the exact same academic expertise or organizational affiliation, and the distribution of gender and academic groups is maximized. While all groups have a similar composition in a broad sense, individually each team remained remarkably unique. For example, all teams had at least one engineer, however, they came from different areas of engineering such as chemical engineering, computer engineering, energy engineering, and other engineering fields.

2013 SISE Research Projects

In 2013, SISE focused on energy and sustainability challenges through the lens of transportation. The following four projects were developed for the SISE 2013 program:

- Market Development & Outreach to Increase Community Use of Alternative Fuels in Highland Park, IL
- Sustainable Distribution Strategies
- Consumer Ready Natural Gas/Electric Hybrid Vehicles
- Sustainability Innovations for the Department of Defense

Fifty-four participants made up eleven research teams. Ten of the eleven teams had five team members; one team had four members. Projects were randomly assigned. Teams were required to research their assigned project, referencing scholarly materials (both those provided and new ones they sought out), utilize the knowledge of each individual of the team as well as the educational programming provided at SISE, and ultimately develop an interdisciplinary solution to the assigned research project challenge. Solutions had to address the challenge in three areas: policy, science and technology, and entrepreneurship. Solutions also had to innovate in one of those three areas.

Project deliverables included 1) a one-page outline of preliminary ideas for initial review and comment, 2) an executive summary for mentors, 3) a 2-minute elevator pitch for local professionals and entrepreneurs at a networking event (see Figure 6 for photo of networking event), 4) a 20-minute verbal and visual final presentation for a panel of judges, and 5) a 45-second elevator pitch for stakeholders and invited guests at a final networking event. The panel of judges for the final presentations consists of professionals from industry, academia, and a national laboratory, whose role it was to question, critique and comment on the research project solutions, and ultimately rank them based on the three foundations listed above (science & technology, entrepreneurship,



Figure 6: Photo of Networking Event

policy), critical thinking, innovation, and overall presentation.

SISE has found over the years that regardless of all teams exposure to the same resources, lectures, and site visits, each team generates a unique solution without duplication by the other research teams. The distinctiveness of the research project solutions is correlated to the diverse academic and professional backgrounds that comprise each team. The research projects provide fertile ground for interdisciplinary teams to explore the richness of sustainability and energy topics, while the interdisciplinary collaboration and discussion leads to discovery of new concepts and the cross-pollination of disciplines. SISE is not alone in the belief that this is vital to the future of energy and sustainability. Akin to the U.S. Department of Energy (DOE) Basic Energy Sciences’ report, *The Five Grand Science Challenges*, SISE also stresses the importance of integrating scientific research and entrepreneurial endeavors to develop future scientists, business leaders, and policy makers (BESAC, 2007).

The 2013 Winning Research Team

The winning research team for SISE 2013 had 5 members both male and female, ranging in age from 21-28, from states on the east coast to the Midwest, and from varying disciplines. (See Figure 7 below.) For the purpose of this article, this winning research team will be referred to as SusDis1.

The SusDis1 team was assigned the “Sustainable Distribution Strategies” project and was ranked number one by the judging panel at the conclusion of the program. The “Sustainable Distribution Strategies” project consisted of the following description and instructions (abbreviated version):

Participants will select a company with a public logistics, sustainability audit, or energy report that contains information on their distribution method. After gaining a thorough understanding of the company’s distribution channels, conduct relevant field research tasks (e.g. interviews, site visits) to gain further information about the company, its structure, and personnel for dealing with energy savings and product distribution. Produce a re-structured business plan that focuses on innovation in distribution channels. The group will want to investigate alternatives pertaining to packaging materials, shipment methods, modeling algorithms, and technologies to reduce/reuse waste product to increase overall efficiency and reduce fuel consumption to fit the best possible economic scenario for the case study.

The SusDis1 team developed their innovative and creative solution to this problem through an interdisciplinary team approach, combining independent research and collaborative brain storming sessions with knowledge acquired during the SISE sponsored program components, including lectures, panel discussions, site visits, and mentoring (see Figure 8 for photos of site visit). All research teams, including the SusDis1 team, benefitted from the experience and knowledge of mentors and lecturers representing ten businesses, seven universities, two national laboratories, and the founding director of the SISE program.



Figure 7: Team Profile

At the conclusion of SISE 2013, the SusDis1 team presented their visionary solution to the panel of judges. The proposal for their research project was called “Bridging the Gap Between Truck Stop Electrification Supply and Trucker Demand”. They addressed the three foundations as described below:

Technology and Science

Redesign of the Truck: Outfit trucks with truck electrification capability; reduce aerodynamic drag coefficients by changing cab shape, replacing mirrors with cameras, closing the gap between cab and trailer and adding a short boat-tailed rear to reduce GHG emissions; and introduce rocky mountain double trailers to reduce GHG emissions

Policy

Promotion of Electricity Usage for Trucks: Add parking spaces equipped with electricity available to long-haul truckers; implement anti-idling policies when the fleet is parked overnight; and take advantage of federally excised tax exemptions that apply to purchases of idle reduction devices for new trucks



Figure 8: Photos from SISE Site Visit to National Laboratory

Entrepreneurship

Apps and Nav Systems Implementation:

Use local electricity to operate in cab-comfort, communications, and entertainment systems without idling the truck; create a mobile/smartphone/navigation app that finds the most fuel efficient route that enables route planning to include TSE rest locations; use maps developed by Truck Stop Electrification Site Locator (resource developed by U.S. Federal Highway and U.S. Department of Energy) and Shorepower Truck Electrification Project (sponsored by Shorepower Technologies and Cascade Sierra Solutions); and include TSE parking availability at each stop, which is entered by TSE users

This team is just one in many over the last three program years that has flourished from an interdisciplinary education program and team approach to solving some of the world’s greatest energy and sustainability challenges. The SISE program exemplifies a learning environment that encourages innovation, critical thinking, and interdisciplinary collaboration, bringing combined educational methodologies to the forefront of sustainability education.

VI. PARTICIPANT FEEDBACK ON SISE AND INTERDISCIPLINARY COMPONENTS OF THE PROGRAM

Interdisciplinary education is at the core of the SISE program. As a result, it was important for us to understand whether participants were aware of the interdisciplinary nature of our program, whether they appreciate it, how they felt about it, and whether it had any impact on their lives. All participants completed a survey, which contained questions related to these topics.

Participants were asked how well the SISE program integrated different disciplines as it related to energy and a majority of participants (88.9%) felt that SISE integrated different disciplines either considerably or extremely well.

Most participants (96.3%) felt that SISE was a unique experience, with only 16.7% being aware of other educational opportunities that combine interdisciplinary education, professional development and research in sustainability and energy. Aspects most cited as setting it apart from other educational experiences were the diverse cohort, the collaborative research, and the site visits. The diverse cohort speaks to the interdisciplinary nature not only the program but the team as well.

The mission statement for the SISE program is: “SISE will give the next generation of professionals in science, technology, government, and business knowledge of basic energy science and its **relationship with other disciplines** to address the rapid advances it brings to the scientific, technical, and cultural foundations of society. It will promote the inclusion of basic energy science research into entrepreneurial endeavors by future scientists, business leaders, and policy makers. It will also foster awareness of the interdisciplinary issues in society, industry, and technology that shape the ultimate outcome of basic energy science discoveries.”

Participants felt that SISE 2013 met the guiding principles of its mission statement considerably or extremely well (92.6%), and the same proportion of respondents reported that the program had changed the way they think about energy either somewhat, considerably, or a great deal. All but one person felt that the SISE experience would be at least somewhat relevant to their educational development, and all but three felt it would be at least somewhat relevant to their professional development.

The global shift toward more sustainable approaches and practices at the personal, institutional and national levels has grown in recent decades. Industries, businesses, educational institutions, government agencies, and entrepreneurs are embracing sustainable energy and environmental practices, and a social and economic culture of sustainable-minded individuals is emerging. Regardless of the industry, employers are looking for a workforce well versed in the interdisciplinary dialogue of a sustainable future.

SISE 2013 participants provided valuable feedback in open-ended portions of the survey. Here are just a few examples of participants’ comments on the interdisciplinary nature of the program.

“I have not attended anything similar. Living, learning, and collaborating with different types of people with an interest in sustainability to solve a complex problem.”

“If there is another forum that brings together such a diverse group of people focused on solving the same problems, I would really like to know about it. SISE is truly an opportunity to tackle huge problems from a multidisciplinary perspective.”

“It combines not only multidisciplinary backgrounds but also multiple geographic backgrounds of people for a unique diversity not seen in many academic settings. I felt like not only the group I was working with,

but the whole conference body was very diversified but at the same time well educated on sustainable issues, which helped when discussing lectures or project objectives. Because so many different minds were in the same room, unique ideas were sprouted out of many discussions.”

“For Mechanical Engineering students like me, few of them could get the chance to learn about other energy related knowledge except science/technology. From this program, I learned a lot of social science, marketing and policy, which also necessary for engineers.”

VII. CONCLUSION

Educational programs and complimentary courses focusing on sustainability have seen increased attention in the past decade. According to the Association for the Advancement of Sustainability in Higher Education (AASHE, 2012), there are at least 48 sustainability-focused undergraduate certificate programs and 142 minor degrees offered in institutions throughout the United States. Higher education is not only responding to the increased challenges of global climate change, but is also promoting the larger goals of environmental stewardship, equitable distribution of resources, and a healthy economy when planning for future generations (the three e’s of sustainability). Anthony Cortese, head of Second Nature, explains, “Higher education bears a profound, moral responsibility to increase the awareness, knowledge, skills, and values needed to create a just and sustainable future” (Cortese, 2003).

Advances in sustainable trends set the stage for significant future investment in education, research, technology, innovation, and development. Energy presents itself as a unique intersection of disciplinary fields, bringing together the physical and social sciences, technology, economics, business, and urban planning. The SISE program merges the interdisciplinary and essential frameworks of both sustainability and energy to cultivate future leaders to think creatively, collaboratively and innovatively about real world sustainable challenges. SISE’s success increases with each year preparing greater numbers of sustainability and energy conscious individuals across the disciplines.

What is essential to sustainability education? The SISE program demonstrates that interdisciplinary frameworks and best practice, multi-method approaches are fundamental to the advancement of a sustainable society on every level and in all disciplines. The case study research team validates the SISE interdisciplinary sustainability education framework as a growing success.

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