For the Honor Society of Phi Kappa Phi

2018 Excellence in Innovation Competition

The Cooper Union is proud to submit a portfolio for consideration of our project titled:

The Cooper Union's

SEA^{2}M^3

(Sustainable Engineering, Architecture and Art—Materials, Manufacturing and Minimalism) Center

March 21, 2018

Since its founding 159 years ago, The Cooper Union for the Advancement of Science and Art has been a place of exploration, experimentation, and creation. Recognized as a premier institution for instruction in the arts, architecture, and engineering, Cooper Union is also a leader in making education financially accessible to those who may not otherwise be able to afford it. Over the past 150 years, our Irwin S. Chanin School of Architecture, Albert Nerken School of Engineering, and School of Art have become renowned for their excellence, reflected by the significant impact and influence of our alumni within their fields. Illustrious alumni include Supreme Court Justice Felix Frankfurter, preeminent architects Elizabeth Diller and Daniel Libeskind, renowned artist Alex Katz, and Nobel Prize-winning physicist Russell Hulse, among many others.

Peter Cooper, industrialist and philanthropist, founded the Cooper Union because he believed that education was the key to the creation of significant contributions to society. His legacy has lived on through the thousands of graduates who continue to contribute to societies on a daily basis throughout the world. The Cooper Union's focus on openness and accessibility extends to education programs for adult learning and through K-12 outreach. Our institution's signature community programs provide free pre-college art studio training, STEM immersion programs, and engineering skills training to New York City's underserved youth, and an extensive free retraining program to immigrants and refugees.

For much its history, Cooper Union has been rigorously discipline-centric, and each of the three schools has focused on the development of curriculum and pedagogy independently. While this has yielded incredible results, there is a growing desire amongst faculty, students, and leadership to deepen Cooper Union's commitment to innovation through cross-disciplinary work. Lines between disciplines that were once solid and impenetrable are now blurring, and exciting new opportunities and ideas exist between them.

The Cooper Union's SEA^{2}M^3 (Sustainable Engineering, Architecture and Art—Materials, Manufacturing and Minimalism) Center has served as a model for this interdisciplinary movement for over a decade. The Center underscores Cooper Union's conviction that

enlightened contributions to society emerge from a multi-disciplinary educational foundation. Bringing together the academic training and individual creativity of students from all three Schools, the Center aims to "develop new design criteria that yield materials, manufacturing techniques, habitats and lifestyles that are sustainable, and that, ultimately, reduce the chasm between the rich and the poor."

SEA^{2}M^3 Director Professor Toby Cumberbatch created the Center to empower students to seek solutions to real-world engineering challenges. By drawing upon reciprocal learning and cross-disciplinary engagement, students have had the opportunity to create designs and then test and implement them in the field. Professor Cumberbatch has challenged students to unite their respective engineering, architecture, and art backgrounds to design products that can serve to better conditions for the extreme poor.

In 2005 a group of students from the SEA^{2}M^3 Center traveled to Africa to the Upper East region of Ghana, a remote area with limited resources. In this region fluoride levels in the water are extremely high. Over the course of five summers students confronted this problem, designing and installing a solar powered pump at a borehole and identifying laterite, a natural material found in regional soil, as a key component in creating a simple and affordable filtration system. They also collaborated with regional officials to have a water lab constructed. Another group of students worked in the North Western region to design an update to traditional beer stoves, enabling users to operate the stove using 50% less wood, thereby preserving valuable local reserves. Through yet another initiative, students helped to create an updated design for a traditional mud building using sustainable and indigenous materials.

These projects had limited impact in the field due to reasons connected to resource availability and regional constraints, as Professor Cumberbatch outlined in writings and presentations (see Appendix C). Despite the challenges, students involved in these initiatives were able to participate in multi-disciplinary problem solving, engage in the process of carrying a product design from concept to implementation, and learn how to coordinate and communicate in the field with a wide range of community stakeholders.

Two projects that emerged from the SEA²M³ Center have had a wider impact and are continuing to expand their reach. The first project, RiFSK (the Refugee in Flight Shelter Kit), had its origins in 2008, when Professor Cumberbatch challenged a group of first-year students to create a sustainable dwelling. The structure needed to be off-grid and habitable year-round in varying climates. The structure had to encompass basic heating and cooling systems, a water collection function, and waste disposal, and be both durable and comfortable. In order to have the structure "translate" to a concept that could work to serve the poorest of the poor globally, students had to use easily found materials that are abundant in urban centers around the world such as plastic bags, plastic bottles, newspapers, and cardboard, and to create instructions to build the shelter from basic pictograms.

Working collaboratively over the course of the semester, the students created a structure that incorporated a waterproof tarp made from disposable plastic shopping bags, plastic bag ropes plaited into cables, floors and walls built with bricks created out of juice cartons, and windows comprised of flattened plastic bottles. Dubbed RAGS (the Reuse of Available Garbage for Shelter), the design stood as a concept for addressing both the need to affordably house individuals in poor and transitional circumstances and the benefits of repurposing the enormous amount of plastic, glass, and paper waste generated by modern societies. In creating this shelter design, the students had the opportunity to contemplate concepts related to sustainable engineering, reuse of materials, and the needs of the urban poor.

In subsequent years, over 150 art, architecture, and engineering students worked together to recreate and refine the RAGS design. They also began to turn their attention to the possibilities for implementation of their ideas. Learning of the plight of refugees in Somalia who were living in shelters comprised of no more than plastic sheets and sticks, the students began the creation of RAMESSES (Reuse of Available Material, Energy, Structures and Supplies for Emergency Shelter). The objectives of the design were to create a shelter that would provide protection from the elements, personal security, and a space in which residents could regain a sense of dignity and self-determination after the trauma of displacement. The shelter would have to work within the severe constraints of the availability of materials within refugee areas.

Students used both traditional yurts and the Somalian aqal as models for RAMESSES. The shelter design, a 4 meter diameter, 2 meter high geodesic dome, was comprised of strips of bamboo held together with sisal twine and covered with coconut matting. The floor of the dome was covered with a tarp attached to the frame in such a manner that the structure could accommodate up to 3 centimeters of water; this design element was included to maximize inhabitants' comfort during the rainy season. An umbrella with plastic flaps, which could be rolled down during the heaviest rains, was also integrated into the structure's frame. During the dry season, this umbrella could be supported above the dome to provide shade and regulate the internal temperature. Apart from the tarps, the dome's materials were all biodegradable and could be sourced as geographically close to the point of end use as possible.

Upon completion, the prototype received interest from representatives at the UNHCR (United Nations High Commission for Refugees). While the political situation in Somalia made the prospect of travel to that region too perilous, SEA^{2}M^3 Center students and faculty had the opportunity, with UNHCR partnership, to bring the RAMESSES design to the Mentao Refugee Camp on the border of Mali and Burkina Faso. The working group from the Center studied the real-life conditions of the camp and received feedback from UNHCR representatives and from the refugees themselves, some of whom tested the design. The students learned that the RAMESSES prototype structure had to be stronger, better ventilated, and needed an external net of fine mesh to protect against extreme rainstorms. Both the head and deputy head of shelter at UNHCR supported the further development of the project and encouraged the SEA^{2}M^3 Center to continue its efforts.

Students in following years, from 2008 through 2015, built upon the information gained from that initial trip to refine the design for a locally sourced and resilient shelter. Professor Cumberbatch also drew students' attention to an additional need that prototypes should address: the situation of refugees "in flight" to organized camps. The students narrowed their objective to design a prototype that is portable and lightweight and able to withstand the strong winds, harsh sun, torrential rain, and high humidity of Sub-Saharan Africa. Divided

into groups over multiple semesters, students have focused on different aspects of design creation, including project coordination and website uploads, overall design, kit development and evaluation, kit manufacture and delivery, situation and needs, and materials procurement. Maintaining relationships established with UNHCR representatives, the students are continuing work on the RiFSK, with the ultimate goal of once again testing and implementing these designs in the field.

Another example of the highly engaging and successful work the from the students involved with the SEA^{2}M^3 Center is the ongoing design process and refinement of "SociaLite," a prototype lantern and light distribution system that seeks to alleviate the challenges associated with "light poverty." As one in five members of the world's population does not have access to a clean light source, many individuals live in the dark from sunset to sunrise. This limits individuals' ability to pursue home-based income earning endeavors such as sewing or typing, prevents children from completing homework, and can cause significant safety threats when navigation has to happen by touch alone. Those who live in remote and rural communities, or who have the fewest resources, are at particular risk.

In 2006 Professor Cumberbatch first issued students the task of designing a rechargeable lantern for use in the most remote and impoverished regions. Bearing in mind the limitations of the environment in which the lanterns would be used, and with sustainability at the forefront of their goals, the students had to come up with a light source that would be robust, simple to operate, would incorporate locally-sourced material, and would be able to withstand local climate and conditions.

Once again working collaboratively and drawing upon their cross-curricular strengths, the students came up with the initial design for SociaLite. In the summer of 2007, SEA^{2}M^3 Center students and mentors from local communities had the opportunity to test the prototype in the community of Nambeg, in Ghana's Upper West region. The interdisciplinary group received feedback from community members regarding specific usage needs. The SEA^{2}M^3 Center

established international partners, which brought undergraduate students from Rwanda and from Wa Polytechnic in Ghana into the collaboration. The collective, group approach led to incorporating plastic hair relaxer containers, bicycle spokes, and juice bottles—all of which were affordable materials that could be found locally—into the design.

Since 2006, as an ongoing design challenge for SEA^{2}M^3 Center, students have continued to work on the improvement and implementation of the SociaLite. The lantern is now powered by a 6V battery available in local markets and can be charged at a central community changing station. Each lantern requires only a weekly recharge. The kits are portable enough to be delivered to even the remotest communities, and those communities can then be taught to construct, install, and operate the systems. As of now there are four communities that have built and are operating SociaLite systems, and there are plans to expand to a further ten in the near future. As the only lighting program that currently serves these isolated rural regions, SociaLite has the potential to have an even wider impact through future development. The New York Times called the SociaLite "an ingeniously designed system." The Economist dubbed it a "novel approach." Partly due to the success of SociaLite, SEA^{2}M^3, and its other projects, Professor Cumberbatch has been invited and delivered numerous lectures and attended global conferences to discuss the mechanics and promise of the SociaLite (see Appendix C).

Involvement with SEA^{2}M^3 Center initiatives has had a profound impact on many students' academic and professional careers beyond their time at Cooper Union. Of the approximately 75 students who have participated in field work in West Africa, 6 have gone on to complete PhDs, 3 have served as Fulbright scholars, and 2 have received National Science Foundation Graduate Research Fellowships programs, among many other accomplishments. Several others have gone on to work specifically in international development (see Appendix D).

Graduate Dr. Anurag Panda, Engineering '12, works on a U.S.-based microgrid project housed within MIT (GridEdge Solar) and credits his interest in the field to his involvement with SociaLite. Julien Caubel, Engineering '11, traveled back to Ghana after graduation on a Fulbright to study the potential for using steam power in rural regions, and he continues to create designs for

social good. Dr. Katherine Alfredo, Engineering '05, now at Columbia University's Earth Institute, worked on SEA^{2}M^3's fluoride removal project in Ghana and continues to work on innovations in drinking water treatment.

Caitlin Martusewicz, Architecture '11 of Cycle Architecture + Planning worked in Ghana and Laos after graduation and served as a consultant for UNICEF. She has stated "I think if it weren't for SEA^{2}M^3 I wouldn't have been exposed to the things that have inspired me to work equitably, responsibly and with sustainability at the forefront of all of my decisions. As a passive house designer now, energy consumption and embodied energy are the leading drivers for the projects on which I prefer to work."

Dr. Madeline Foster-Martinez, Engineering '12, now a post-doctoral researcher, said that "Working on a SEA^{2}M^3 project means caring about real-world problems. Specifically, it means caring in a profoundly deep and personal way about the people those problems are affecting. This attitude was and remains central to promoting innovation. It provided a firm foundation from which other aspects of design (e.g. reaching across disciplines, remaining user-centered) could seamlessly stem." Specifically commenting on the multi-disciplinary nature of the center's projects, Dr. Foster-Martinez stated "to me, one of the strengths of SEA^{2}M^3 approach is that it didn't feel like we were engineers working with an artist or an architect. We were students working with a common goal. An engineer was not excluded from contributing to an aesthetic aspect of a design, just as an architect was not excluded from a structural aspect."

As a model for multi-disciplinary pedagogy and an example of the power of instruction rooted in real-world problem solving, the SEA^{2}M^3 Center has provided inspiration for Cooper Union across the institution. The mandatory freshman design course for all engineering students is now modeled after the design challenges that the SEA^{2}M^3 Center introduced, and many students go on to engage in the Center due to its influence. Most significantly, last June, selected Cooper Union deans, associate deans, and newly-installed President Laura Sparks convened focus and working groups to address the need to revisit the curriculum school-wide to place greater emphasis on

connectivity among the schools of art, architecture, and engineering. This coincided with the institution's reinvigorated focus on "making"— introducing students to hands-on design and creation toward specific goals that engage real issues in their first year experience.

From these conversations has emerged the idea to create a laboratory space, open to students and faculty from all three schools, to support the cross-disciplinary design learning approach that SEA^{2}M^3 has exemplified. Recently awarded start-up funding through a private funder, the new lab will serve as a catalyst for integration, drawing upon each discipline's strengths through shared training, workshops, and ultimately, freshman design courses. The lab will encompass the full spectrum of tools for making, from a forge to state-of- the-art equipment, and will feature technologies ranging from 3-D printers to robotic arms to virtual reality technologies. Having these new technologies alongside traditional tools for making will position the faculty and deans to reimagine curricula and will create a unique opportunity for students and faculty to engage with each other. By advancing the culture of collaboration initiated by the SEA^{2}M^3 Center, our institution will further enable the organic development of new ideas at the intersections of disciplines. Workshops around problem solving for real-world impact will give students the ability to imagine and enact change.

Students will begin using the lab in their freshman year through a shared workshop composed of students across all majors. As an extension of the engineering freshman design course that adopted many of SEA^{2}M^3 's practices, the first-year cross-school workshop inside the lab will initiate new students' intellectual and technical learning and lay the groundwork for creative, cross-genre studies throughout their education. Building upon this, Cooper Union is now in the process of developing new courses to explore the potential for cross-disciplinary creation (See Appendix E). After year one, each student will have a custom approach to the new space, and students will have the option of pursuing guided or independent study to augment their coursework or to continue their work on design approaches for social good. Studying the most urgent issues of global contemporary societies will be a core tenet, and applications off-site at various locations across New York City, and ultimately across the world, as SEA^{2}M^3 has led the way, will be a curricular goal of the new lab.

The SEA^{2}M^3 Center has influenced the futures of students, inspiring them to pursue career paths in global development and sustainability and to use their academic training and skills to generate positive change. The Center has provided a model for institution-wide advancement, as Cooper Union reassesses and reinvents its curriculum to further embrace cross-curricular interaction and designing for quantifiable impact. Above all, in fulfilling its mission statement, the SEA^{2}M^3 Center has empowered students to collaborate in a multi-disciplinary effort, unifying their backgrounds in art, architecture, and engineering to work towards improving the lives of the global poor.

Appendix A: Designs

Anna Kramer, Anurag Panda, Chloe Rubel, David Berger, Eric Zagorski, Gaurav Namit, Ha Kyung Yoon, Ian Jacobs, Jason Lu, Kevin Tien, Michael Gazes, Nadia Pervez, Nicholas Wong, Paul Miller & Toby Cumberbatch

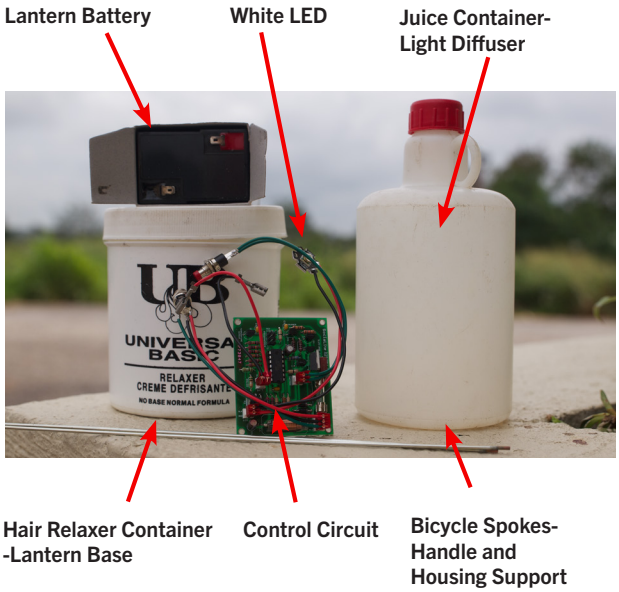
SociaLite

Origin

The challenge to a class of first year, first semester engineering students at The Cooper Union in Fall 2006 was to design "a lighting system for the poorest people on the planet." From this emerged SociaLite, a lighting service for remote, rural off-grid communities.

Design

Supplied as a lighting system in a suitcase, SociaLite is a robust, standalone product able to withstand the climate and the environment, and usage by those unfamiliar with modern technology.

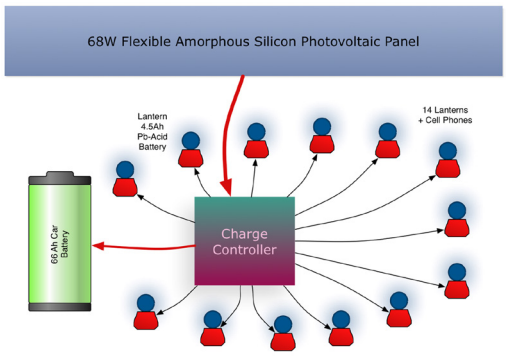


Business Model

After a downpayment of $2.50, users pay $1/month in the form of a charging fee through which they purchase a complete lighting system for about $30/lantern. Currently, three installed systems are each lighting between 50 and 80 households in their respective communities in Northern Ghana.

Engineering

Incorporating locally sourced components where available, SociaLite was designed for local manufacture, assembly and installation, whilst being amenable to local repair and upgrade.



Standard System

CHARGING STATION -
- One 68W Photovoltaic Panel
- One 70Ah Lead Acid Battery
- One Charge Controller
- Fourteen Lantern Charging Outlets
- Four Cell Phone Charging Outlets

LANTERN (80 KITS) -
- One 4.5 Ah Lead Acid Battery
- One White LED
- LED Control and Battery Charging Circuitry

TOOLS FOR SYSTEM ASSEMBLY AND INSTALLATION
Instructions for Assembly, Installation and Maintenance

BAGS

Reuse of Available Garbage for Shelter

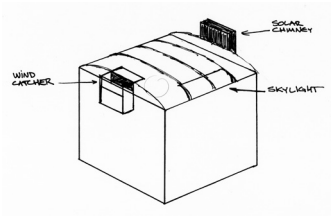
Abhay Masher, Amandine Hess, Angela Neefus, Apoorv Kothari, Carl Malings, Casey Song, Dhrubajyoti Das, Dorina Lleshi, Frank Piscotta, Gabe Kooreman, Gurion Willet, Hwa Young Jin, Jennifer Vanegas, Joanna Cruz, Karen Nemeth, Kevin Tien, Madeline Foster, Melody Ma, Mohamed Diallo, Muneeb Hai, Sophie Rand, Stephen Maniscalco, Sung Lim, William Epstein, Yoon Kim & Toby Cumberbatch

Construct a Shelter

Internal floor area 10 ft x 10 ft
Comfortable in all seasons
Able to withstand elements
Heated (no combustion processes)
Illuminated (no access to electricity)
Habitable by end of semester
Collect and purify water
On site disposal of human waste

Design Goals

Generic Blueprint
Inexpensive
Efficient
Robust Design
Repairable
Sustainable
Aesthetic
Tesselate



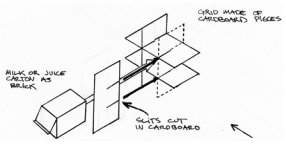
Passive Cooling - Solar Chimney/Wind Catcher

Resources

Plastic Bottles
Plastic Bags
Cardboard
Newspaper
Glass Bottles
Paper Containers
Indigenous Low Level Garbage

Themes

Energy Use and Energy Conversion
Sustainable Engineering
Minimalist Design
Appropriate Use of Materials
Design for the Urban Poor
The Problem of Waste
Fundamental Resources Required to Support Human Existence



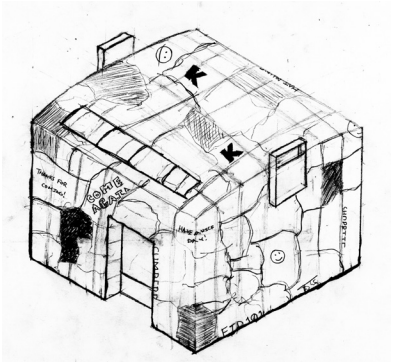
Detail of Cardboard Matrix for Wall Construction


Roof Support Detail Showing Forces

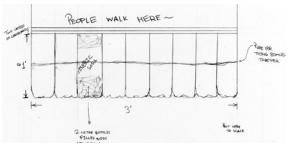

Roof Cover - Tarp Fabricated from Plastic Bags Ironed Together


Wall Construction using Cartons


Complete Shelter Mockup - All Components Demonstrated


Sketch of Shelter Showing Tarp Skin and Passive Cooling


Window - Plastic Bottle and Plastic Tarp

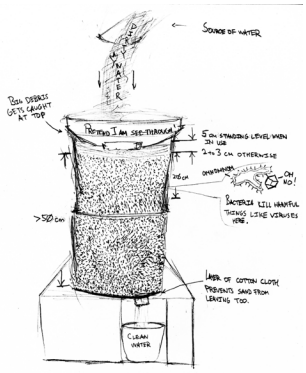


Shelter Foundation Detail - Waterproof Base + Cardboard Floor


Composting Waterless Solar Toilet


Solar Heat Storage System


Rainwater Sand Filter - Pathogen Removal

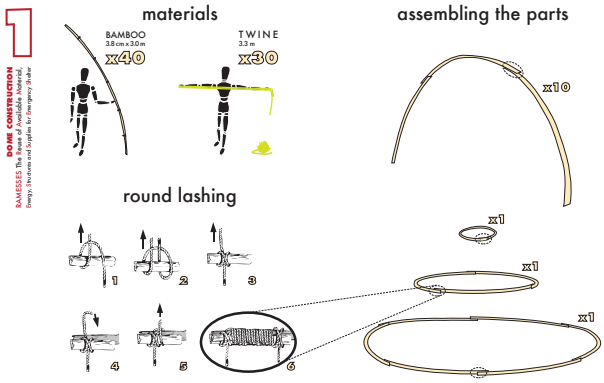


RAMESSES

Sambit Acharya, Keith Caskey, Adam Cerini, Vlad Ciocoi, Joseph Colonel, Harrison Cullen, Ryan Cusack, Alyssa Davis, Cody Hirashima, Matthew Lee, Corina Lupp, Mary Mazur, Srikalyan Megati, Linn Mercier, Kristin Miller, Noel Mollinedo, Kirsten Nicassio, Matthew Nobiletti, Celeste Pfau, Quinee Quintana, Tabitha Rivera, Luz Rizzo, Hannah Rugger, Moises Sanabria, James Sarjeant, Nathanael Steven, Jennifer Tashman, Allison Tau, Sasha Vera, Eugene Wang, Joanna Cruz, David Grahame Shane, Brendan Bannon, Peter North, Yoonah Choi, Natalia Maliga & Toby Cumberbatch

Emergency shelter must address both the immediate needs of the refugees in terms of protection from the elements and personal security—and the more intangible demands of providing a space within which dignity and self-determination can be nurtured and restored. The design must meet these requirements within the constraints imposed by available material, the political and cultural environments, and the trauma of the displaced individuals.

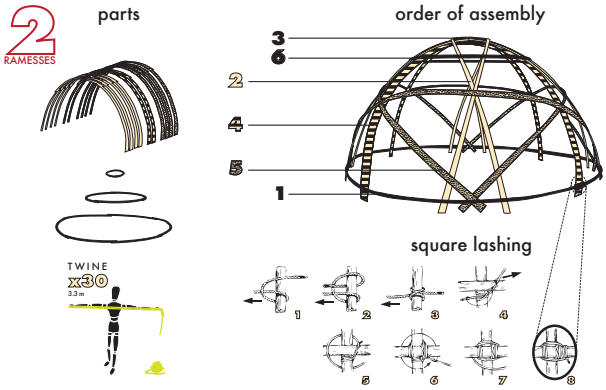
Learning from the traditional Somalian aqal, we have designed a geodesic dome with a diameter of about 4m and a height of about 2m. The frame is constructed from bamboo strips lashed together with sisal twine covered with abaca cloth (in lieu of water hyacinth, grass) serving as a breathable skin.

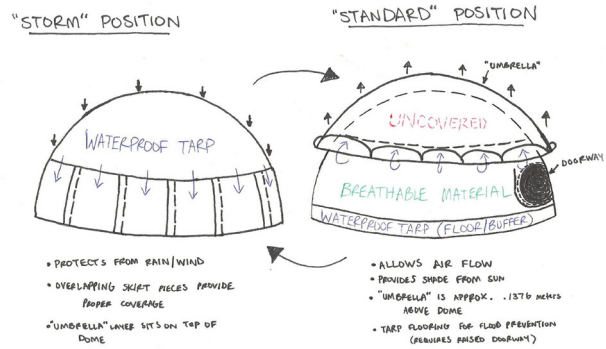


The shelter, designed for self-assembly from raw materials or a supplied kit of parts, uses instructions supplied in the form of pictograms, obviating the need for translation.

To minimize the supply chain length, materials are chosen for their local availability. With the exception of the tarps, all materials used are biodegradable.

RAMESSES: Demo Build
https://www.youtube.com/watch?v=2I3ZtYvHdp8





We use a tarp for the floor to accommodate standing water; another tarp provides an integrated umbrella. In the rainy season the flaps are rolled down; in the dry season, the umbrella provides ventilation and shade.

The outcome is a shelter, assembled on site using local materials, that better suits culture and climate. It is to be tested in Dadaab, Kenya later this year.

Appendix B:
Photographs and Video from the Field

RAMESSES: Mentao (2014)

RAMESSES: Mentao (2014)

RAMESSES 2.5: History and Progress

https://www.youtube.com/watch?v=n5iQTQfniMI

Featuring Cooper Union students

Sambit Acharya (CE'16)

Harrison Cullen (BSE'16)

Matthew Kaufmann (CE'16)

Natalia Maliga (ART'16)

Mengxi Shi (BSE'15)

SociaLite overview

Lighting System in a Suitcase

Complete Kit - $2400

- Parts for 80 lanterns
- Solar Panel
- Car Battery
- Charging Center
- Assembly tools

Local Entrepreneurs

- Assembly
- Installation
- Maintenance
- Repair
- Lantern charging
- Fee collection

Community voting to install SociaLite

Woman using SociaLite, Nambeg, Ghana, January 2008

Students gathering feedback, Nambeg, Ghana, June 2007

Featured: Yoo Rhim Choi (CE '10)

Appendix C:
Press, Publications, and Lectures

***The New York Times* Innovations in Light**,

February 2, 2012

https://opinionator.blogs.nytimes.com/2012/02/02/innovations-in-light/

***The Economist* Lighting the Way**, Q3, 2012

https://www.economist.com/node/21560983

Self-Assembled Solar Lighting Systems

T.J. Cumberbatch, D. Berger, M. Gazes, P. Momori, N. Ayikutu, C. Mtiamoah, F. Akorli, D. Anipa and F. Akuffo

Proc. ISES Solar World Congress, October 11–14, 2009, Sandton Convention Center, Johannesburg, South Africa

Lighting the Middle of Nowhere, in Gay, J., et al. 126, (2014). Lighting People's Cities. Novato, California, ORO Editions.

Lessons from Africa: Bringing the Mud Hut into the 21st Century

Caitlin Martusewicz, Deborah Ferrer, Noah Garcia, Leila Rzyska, Julien Caubel, and Toby Cumberbatch

The Cooper Union, New York, NY USA

Lessons from Africa—Sustainable Design and Engineering

Toby Cumberbatch

UB-NE ASEE Conference 2009

Additional mentions in:

Business Week

Steelcase

CBS News

Voice of America

Prism Magazine (Using What's at Hand, 2007)

Architectural Lighting Magazine (SociaLite, 2011)

Ana Shell Media Press Singapore (Changing the World One Light at a Time, 2014

TEDx November 28, 2011—Miller Theater, Columbia University, New York City

https://www.youtube.com/watch?v=fsz-1IeOY-s

Appendix D: Student Impact

Dr. Madeline Foster-Martinez CE '12

Madeline graduated from Cooper Union with a degree in Civil Engineering in 2012. She studied Environmental Engineering at the University of California Berkeley, where she completed a masters in 2013 and a PhD in 2017. She is now a post-doctoral researcher at Louisiana State University's Center for Coastal Resiliency.

https://www.youtube.com/watch?v=uAWXTxD0Ydg

"It is difficult to find a way in which [SEA²M³] did not affect my experience and trajectory! My first exposure to SEA²M³ was a freshman design course (EID101). I had just transferred schools in order to pursue engineering, but I was still nervous that I had not chosen the right career path. My classmates and I were challenged to build a trash house—a wholly sustainable and functional home—using only the lowest forms of refuse (i.e. plastic bags, plastic bottles, and cardboard). Similar to the cyclical way in which nature operates, we took the problem of excess waste and used it to create needed housing. It was through this project that I discovered the fundamentals of engineering and cemented my passion for becoming an engineer.

The following summer I was fortunate to travel to Ghana as part of SEA²M³'s Lessons from Africa project. Living in Jirapa, Ghana, completely changed my perspective on engineering design, development, social constructs, education, gender—the list goes on! The beauty of SEA²M³'s projects and Professor Cumberbatch's approach was that we were free to lead the projects as we saw fit. We were not only allowed but encouraged to let go of previous plans and concepts in order to immerse ourselves in all aspects of the place.

My connection with Ghana remains strong. I returned this past summer to help teach an oceanography course and to go back to Jirapa. I met many new people who welcomed me simply based on knowing I was a Cooper Union alum. The fact I was welcomed back in this way is a testament to the commitment of the SEA²M³ team to the projects we undertake.

The experience gained through SEA²M³ directly contributed to my receiving an NSF Graduate Research Fellowship, which allowed me to pursue to a PhD at UC Berkeley. During my exit seminar at the completion of my PhD, my PhD advisor introduced me by saying that there were two things I was not willing to compromise on: any technical aspects of engineering and the applicability of the result. I can directly attribute these qualities to my experience in SEA²M³. We learned through firsthand experience that it is not enough for results to be correct or interesting; they should also be useful.

All of our projects were done in conversation with others. It was clear from day one that engineering in a vacuum is meaningless. None of our projects—from RAGS (reusing available garbage for shelter) to SociaLite to Engineers as Teachers to the pito stove—would have been successful without open collaboration.

To me, one of the strengths of SEA²M³ approach is that it didn't feel like we were engineers working with an artist or an architect. We were students working with a common goal. An engineer was not excluded from contributing to an aesthetic aspect of a design, just as an architect was not excluded from a structural aspect. While in Ghana, this inclusion extended far beyond the students working on the project; it extended to everyone involved. For example, while working on the redesign of the pito stove, the women who use the stoves were integral to the process from day 1.

SEA²M³ projects taught me that engineering does not have to be so narrow. We can and should branch out of our subdisciplines. As students, we were not confined to one project. We were encouraged to be involved in as many projects as we wanted.

Working on a SEA²M³ project means caring about real-world problems. Specifically, it means caring in a profoundly deep and personal way about the people those problems are affecting. This attitude was, and remains, central to promoting innovation. It provided a firm foundation from which other aspects of design (e.g. reaching across disciplines, remaining user-centered) could seamlessly stem.

This attitude immediately made sense to me. I started at Cooper Union two years after Hurricane Katrina. Coming from a city still recovering from an engineering disaster, I could see how SEA²M³'s approach was not only radically different, but desperately needed. Interdisciplinary teams, where the people the designs serve are put first, are the only way to move forward and work to build a world that can be sustained for generations to come."

Caitlin Martusewicz Archtecture '11

Caitlin joined Cycle Architecture + Planning in 2014 and has since worked on a broad range of the firm's sustainable planning, residential, and commercial projects. Previously Caitlin's passion for sustainable development led her to work on the design and construction of community development works in rural Ghana including an orphanage, solar-powered WASH facilities, and volunteer housing with an Austrian NGO. She also worked as a consultant for UNICEF and in partnership with the Ministry of Education of Laos to develop national standards for the construction of pre-primary schools. Caitlin is a Cooper Union Irwin S. Chanin School of Architecture graduate, an Irma Weiss Fellow, and a certified Passive House designer.

"In the years after working with Professor Cumberbatch and SEA²M³, I have come to learn and re-learn many of the themes that were central to our investigations and which remain relevant to the work that I do. [The] design prompt for a mud hut for the 21st century—a net zero or net positive inhabitation in Ghana—which could cycle and re-cycle its materials, is still a driving theme in the work I do now as an architect in Brooklyn. Through working for 5 consecutive summers in Ghana with [SEA²M³] and then independently, I learned a skepticism of "modern" and "contemporary" architecture, as understood in the Ghanaian environment, or rather a building not-suited to its environment and therefore requiring untold amounts of energy to manufacture, maintain, heat and cool. I think if it weren't for SEA²M³ I wouldn't have been exposed to the things that have inspired me to work equitably, responsibly and with sustainability at the forefront of all of my decisions. As a passive house designer now, energy consumption and embodied energy are the leading drivers to the projects on which I prefer to work.

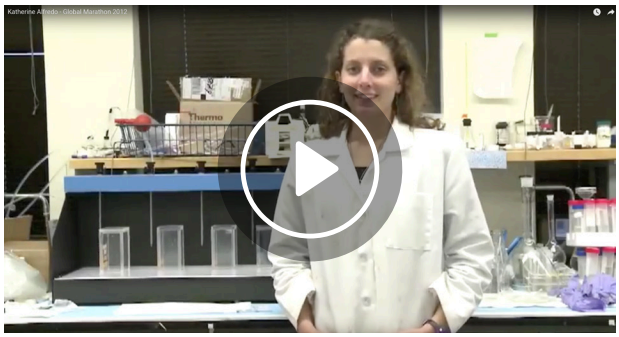
The shared input from the range of backgrounds marked by the engineers, artists and architects… made us consider so much more than our own understanding. And the conversations were as diverse as our backgrounds and would touch on aspects of our soon to be professional lives that might not seem inherently professional, but had everything to do with the real world, i.e. issues of racial identity, gender equality, human centered design stand out to me now as some of the most eye-opening.

During my time at Cooper, I don't think anyone was a bigger proponent for "getting artists, architects and engineers in the same room" as Toby. [A] result of the center, from my standpoint at least, was my… real respect for traditional knowledge and the mind shift from "designing for" to "designing with" back when no one was really talking like that."

Dr. Katherine Alfredo Engineering ’05

Katherine received a Bachelor’s Degree in Civil Engineering from Cooper Union and her PhD from UT-Austin researching fluoride and drinking water treatment. Katherine’s interest in drinking water issues in rural, developing areas of the world led her back to Ghana on a 2008–2009 U.S. Fulbright Fellowship. After completing her PhD, Katherine held a short-term research position at the American Water Works Association policy division in Washington D.C. focusing on water quality compliance and policy. At the Columbia Earth Institute, she works on a variety of projects ranging from understanding the water rates structure in the United States, linking agricultural water usage with long term water quality issues in developing countries, and defluoridation evaluation and monitoring in India. Upon return from her recent Fulbright-Nehru Postdoctoral Scholar tenure in India, Katherine began her research position at DC Water.

https://www.youtube.com/watch?v=0mPB3piPOfQ



Julien Caubel ME ’12

After graduating from Cooper Union, Julien received a Fulbright scholarship to travel to Ghana to continue research on sustainable energy production for rural communities in the African nation. Working to create a source of economically and environmentally sustainable energy to ameliorate infrastructural deficiencies in rural communities, Julien designed, built, and tested a simple steam engine to power electric generators, water pumps, and other equipment. Julien’s trip to Ghana allowed him to refine his creation and set about advocating and implementing it in rural and relatively isolated communities that have unmet infrastructural needs. After his Fulbright, Julien began work toward a PhD at UC Berkeley.

“In 2010, I spent the summer in Ghana as part of a SEA2M3 research project on the design of sustainable housing for remote communities in the developing world. I collaborated with a Cooper Union architecture student and local craftsmen to design and build a small home using mud bricks and bamboo: environmentally sustainable building materials that can be acquired locally and inexpensively. Working in a team with such a wide range of cultural and professional backgrounds, my communication skills grew immensely, and I learned the importance of incorporating others’ ideas and viewpoints into the design process. I quickly realized that I really enjoy working

with such a diverse group, and that we had come up with a design incorporating techniques, features, and ideas that I would never have encountered otherwise. Furthermore, the experience of living in a small, agricultural community fundamentally changed my views on the relationship between society and the resources it consumes. I witnessed the general scarcity of clean water, cooking fuel, and other basic amenities, and the enormous daily effort that people, often young women, expend into gathering these resources for their homes. The experience completely altered my professional and personal paths, and I have since focused on developing sustainable energy technologies for the developing world. In 2012, I returned to Ghana as a Fulbright Fellow to research biomass-to-electricity systems, and I am currently pursuing my PhD in Mechanical Engineering at UC Berkeley, where my research focuses on the design of clean and efficient cookstoves for the one billion households still relying on biomass fuels. Overall, that first summer in Ghana with SEA2M3 set me on a path to amazing professional opportunities in a field that I love, and the experience still profoundly influences both my work and personal outlook today."

Dr. Anurag Panda Engineering '11

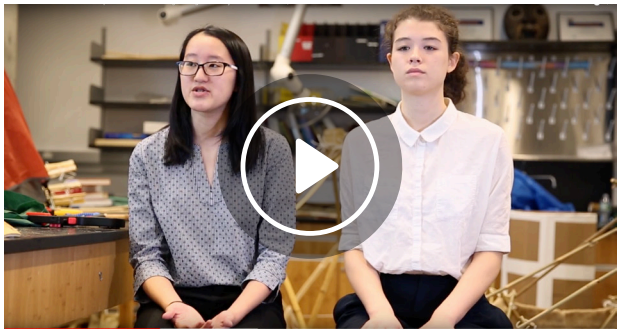
Anurag is a researcher with expertise in optics, photonics and electronic materials. He is equally fascinated with the workings and development of optoelectronic technologies and with the societal implications of their deployment. Currently, he develops new materials and technologies to enable large-scale solar energy harvesting. He also researches the market conditions and policies that govern deployment of emerging solar technologies, and their resulting long-term impact on society and environment.

"My participation in Socialite through my four years at Cooper trained me to ask the often overlooked and sometimes uncomfortable questions that result from technology development. What are our pathways for sustainable and equitable development for all? What should be preserved and what discarded on our path to development? How should the negative externalities resulting from new technologies be distributed in society? Relentlessly asking these questions has not yielded any easy answers but they have helped keep these ideas in the forefront of technology design considerations of the teams I have been involved with since Cooper."

Appendix E: Institutional Impact

President Laura Sparks and students Courtney Chiu ChE '21 and Hannah Quirk ME '21

https://www.youtube.com/watch?v=ZcwaxfCbSkg



Proposed Multi-Disciplinary Classes that are now in development due to the success of SEA²M³

Urbanism, *Construction and Housing affordability*: With the transformation of the 'traditional nuclear family', with the hybridization of work and live spaces, with the necessity of shared spaces, we realize that the very urgent social realities facing an expanding urban society are not being addressed as an integrated whole. This workshop will focus on affordable urban housing as a critical social and material issue, tied to the innovation of construction practices as well as strengthening community engagement and investment.

Public Art/Public Space: With a new Public Art/Public Space studio workshop, students will be able to transform Cooper Union's entry plaza at Astor Place through a partnership with the NYC Department of Transportation. Each year Architecture, Art and Engineering students will work together in a public collaboration to design and build a large-scale installation for the plaza.

Architecture and Reading the City: Students will study the characteristics of 25–30 individual buildings in a single city or region in relationship to a broader urban context. They will engage in the construction of analytic models, large scale details and three-dimensional transformations toward a comprehensive understanding of each building.

Virtual Reality: A cross-disciplinary workshop to facilitate designs by artists, architects and engineers. VR head-mounted displays (HMDs) such as the Oculus Rift and HTC Vive have the power to change the way buildings are designed and communicated before they are built. Students will also learn to perform model optimization to bring BIM data into a VR environment.

New Arenas for Advanced Fabrication: New advanced electives in which technology would be a crucial component. For example, in-house printed circuit board fabrication for interdisciplinary use; facilitating a new Chemical Engineering elective on prototyping drugs using 3D printers; milling, printing and testing structural components; new potential for sculpture and material studies in the fine arts; new methods of architectural representation and speculation.