

Title: Pilot Project Proposal for Living Monitoring Systems

Principal Investigators: Dr. Michael E. Chang, Deputy Director, Brook Byers Institute for Sustainable Systems; and Dr. Dana Hartley, Undergraduate Coordinator, School of Earth and Atmospheric Sciences

Prospective SURF Applicants: Gertrude Parvur (EAS), Galen Raney (EAS), Richard Leo Ludwig (PUBP), Melat Hagos (EAS), and Ming Chen (INTA)

Summary: This project will support 8 Sustainable Undergraduate Research Fellows (SURFers) engaged in collectively creating an engaging, interactive, adaptable, and living monitoring system that interfaces with the activities, operations, and prevailing conditions that are centered on the Living Building at Georgia Tech, and expanding outward through the scales of the campus, the city, the region, and the globe. The monitoring system will address the cascade of scales as they impact the Living Building through each of the seven performance petals that are key to the Living Building Challenge: Site, Water, Energy, Health, Materials, Equity, and Beauty.

The monitoring system will be designed and built by students using STELLA-Pro Systems Modeling and Simulation software as the underlying platform (<https://www.iseesystems.com/store/products/stella-professional.aspx>). STELLA is a powerful but intuitive graphical programming software package that is exceptionally well suited for capturing the dynamics of living systems. Further, its user-friendly interface enables expert and lay people alike to “play with the knobs and dials” to change settings and explore consequences across multiple connected, complex systems (e.g. water, energy, and health). SURFers will gather each week during the Fall 2017 and Spring 2018 semesters to participate in STELLA “hack-a-thons” in which they will quickly create prototypes that use observable data to create simulations and models that represent the performance of the Living Building, its occupants, and its environs. An example STELLA program is shown in Figure 1. In this program, the systems that govern Atlanta’s electricity, transportation, water, and population are interconnected and students are challenged to explore the linkages among the systems and how changes in one system can impact others. Similar programs will be created for the Living Building that address and connect each of the petals to each other, and to other natural, social, built, and economic elements extending outward from the Living Building.

The project will be further supported by re-centering the course, *EAS 2420: Environmental Measures of Urban and Regional Change*, and placing the Living Building Challenge at the center of the semester-long Atlanta themed case study that is used in the class now. The objective of *EAS 2420* is to discern that metropolitan areas are comprised of complex and inter-dependent human, built, and natural systems; to learn to develop meaningful measures, collect and analyze data, and communicate findings that characterize these systems, their inter-relationships, and their impact on the environment; and to explore the mechanisms that may be used to effect change in these systems. There are no pre-requisites for the class and in the past students from all six colleges at Georgia Tech have enrolled. Here they learn the fundamentals of systems thinking as it applies to the urban environment, and how to apply these principles through the creation and execution of complex computer models that they build from scratch using STELLA-Pro. *EAS 2420* will be required for all future SURFers. The prospective SURF applicants listed above are all students currently enrolled in the Spring 2017 section of *EAS 2420*, and their inclusion here is notable due to their expressed interest in applying for the inaugural class of fellows.

Apart from the creation of a living monitoring system for the Living Building, this pilot project will lead to the development and launch of a new Vertically Integrated Project (VIP) that will start Fall 2018 (with planning and recruitment commencing during the pilot project as described in the timeline below). All SURFers and students completing *EAS 2420* will be immediately eligible for the VIP, and others will be recruited. The VIP is envisioned as a solution to the problem that most “building dashboards” lose their novelty soon after building commissioning and become stale, obsolete, or inoperable within a few months of their debut. Instead, a living monitoring system needs to adapt as the building moves through its life cycle, as its occupants transition through, and as the climate and environment in which it resides evolves. Students in the future may have very different interests and concerns than students today. They will benefit from the efforts of those that came before them, but so too will they be able to adapt the monitoring system to their contemporary interests. In planning for the VIP, the principal investigators have

discussed the timeline and requirements for launching a VIP with Professor Ed Coyle, and confirmed the appropriateness of the plan.

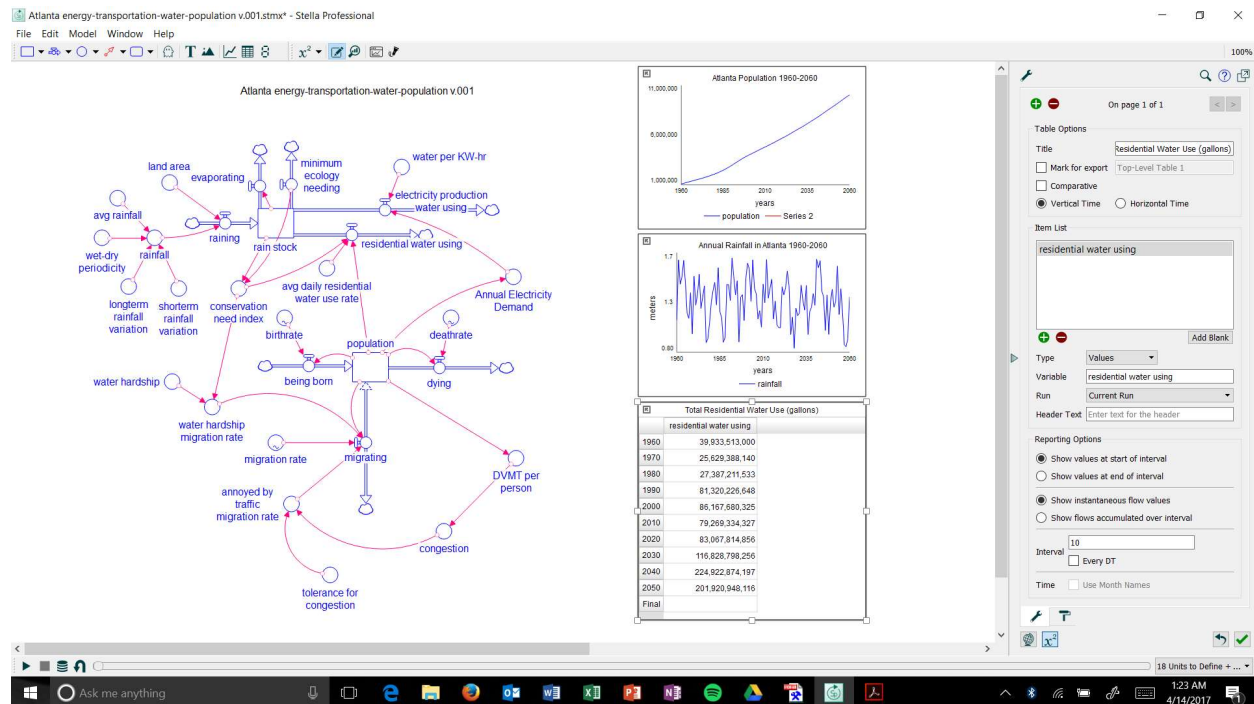


Figure 1. Example of integrated Atlanta Energy, Transportation, Water, and Population STELLA simulation model used in EAS 2420.

Drs. Chang and Hartley have been collaborating on research and education programs for more than 20 years at Georgia Tech. Most recently, they are co-teaching the Spring 2017 section of *EAS 2420*, which is the springboard for this proposed pilot project. In his role as the Deputy Director of the Brook Byers Institute for Sustainable Systems, Dr. Chang facilitates large teams of investigators to pursue and win very large extramural grants to support research related to sustainability. Most recently, he led a team of 52 investigators from 5 universities through a two-year effort to try to secure a grant from the NSF for an Engineering Research Center for Gigatechnology (10 years, ~\$40M). The competition is completed, and results are expected to be announced by June 2017. He is currently working on building inter-disciplinary teams to pursue opportunities in Food, Energy, and Water Systems (FEWS), and in Climate Science and Engineering. He also serves as the faculty advisor for the student group, Students Organizing for Sustainability (SOS), and for Chi Psi fraternity. For the last five years, each Fall he has taught a section of GT1000, and the last two years has co-taught GT1000 with Howard Wertheimer, Director of Capital Planning and Space Management. Dr. Chang and Mr. Wertheimer recently received permission to develop a GT1000 section that will focus on sustainability and will be offered beginning Fall 2017. Dr. Hartley has been teaching GT1000 for Earth and Atmospheric Science majors for over a decade. She also teaches other EAS courses such as Atmospheric Chemistry and Physics of the Weather. Dr. Hartley served as Director of Undergraduate Studies during the design and opening of the Clough Undergraduate Learning Commons. She played a strong role in student centric planning of the building. She was awarded the G. Wayne Clough Friend of the Student Award by ODK in 2008 and in 2015. She was the GT1000 Instructor of the year in 2013, and Outstanding Faculty Academic Advisor in 2016. She is the Homeless Student Liaison and coordinates STAR – Students’ Temporary Assistance and Resources, which supports students in need with food, housing, clothing, finances and connections. By way of their professional and personal interests and values that focus on living systems, as exhibited through these and other activities, their resourcefulness in securing internal and external real and in-kind support for their work, and through the cultivation of a pipeline of undergraduate students, the Principal Investigators are confident that this pilot project will be sustained beyond the term of the pilot.

Budget: Release time for Senior Personnel Chang and Hartley will be covered by the Brook Byers Institute for Sustainable Systems and the School of Earth and Atmospheric Sciences, respectively. An honorarium of \$1080, paid in two installments (September 2017 and January 2018), will be provided to each of eight (8) Sustainable Undergraduate Research Fellows (SURFers). The expectation is that the SURFers will meet for “hack-a-thons” no less than 3 hours per week during the Fall 2017 and Spring 2018 semesters (i.e. 8 Fellows meeting 3 hours per week for 30 weeks @ \$12 per hour). Materials and Supplies include eight (8) perpetual student licenses for the STELLA-Pro Systems Modeling and Simulation software @ \$129 per license, and \$328 for weekly meeting costs (including light refreshments).

	Costs
A. Senior Personnel	
Chang (BBISS)	\$0
Hartley (EAS)	\$0
B. Other Personnel	
Sustainable Undergraduate Research Fellows (8)	\$8,640
C. Materials and Supplies	\$1,360
D. Total	\$10,000

Timeline: May 2017 – May 2018 (13 months)

2017							2018					
May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
A	A	A										
			B	B								
				C	C	C	C	C	C	C	C	
								D	D	D	D	D
											E	E

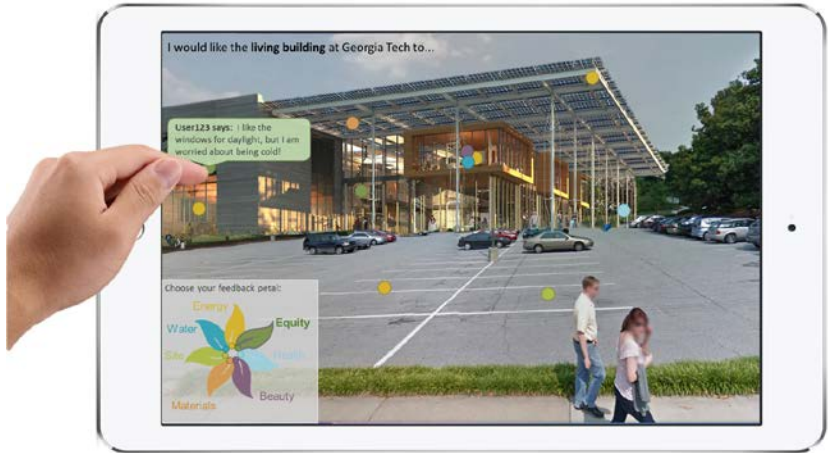
- A. Review existing state-of-art building performance metrics and dashboards, and applicability to Living Building 7 petals (Site, Water, Energy, Health, Materials, Equity, and Beauty); prepare and disperse advertisements for Fall SURFer recruitment.
- B. Recruitment and selection of inaugural SURFer cohort.
- C. SURFer weekly metric hack-a-thon; student driven Vertically Integrated Project planning; prepare grant applications for additional external sponsored funding; solicit external partnerships.
- D. EAS 2420 course – Environmental Measures of Urban and Regional Change including semester-long student case study: Georgia Tech Living Building and its Environs, and STELLA-Pro Systems Modeling and Simulation software training.
- E. Dashboard prototype reveal; Launch Vertically Integrated Project with inaugural SURFer cohort and recent EAS 2420 students; recruitment of SURFer Class 2.

LIVING BUILDING COMMUNITY CROWDSOURCING:

Developing an Interactive Augmented Reality Viewer to Capture Community Feedback

1. PROPOSED PILOT PROJECT & RESEARCH SIGNIFICANCE

The decisions made when a building is designed are critical to its future occupants' satisfaction, comfort, and productivity. However, during a building's design and construction there are rarely opportunities for future building occupants to give feedback on the design. Feedback loops for occupants are typically established after a building is occupied [1]. Proactively engaging with future building occupants is critical to ensure the building best serves people of diverse backgrounds while reducing the risk of costly fixes in the future. This is even more crucial in the Living Building Challenge context where resource consumption limitations are extreme.



Mock-up of Proposed Interactive Augmented Reality Viewer App with the Living Building Model Overlaid on the Real Project Site

Incorporating future occupant feedback into a building's design has well established benefits [2], however, to collect this feedback a proposed building's design and functions envisioned by the leaders must be communicated to future users in an effective way. This is a challenge as it can be difficult for those not involved in the design process to understand proposed building design and operations. In addition, communications must appeal to heterogeneous populations to ensure the feedback loop is accessible and inclusive to a variety of audiences. Virtual and augmented reality provides an opportunity to fill this gap by effectively simulating 3D spatial representations of the proposed building. This technology has the potential to allow visitors to view and experience the building from several perspectives, gather direct feedback from users that captures their insights on arbitrary elements, and deliver diverse community ideas to inform building design decisions in a more equitable manner.

This pilot project proposes the deployment of a virtual experience of the proposed Living Building design at the actual building site to engage interested people or passersby by enabling them to explore the proposed building and give feedback. Users will interact with an app deployed on an iPad, which displays the proposed building model in augmented reality. Users will be able to experience the building exterior site as well as interior spaces. In addition, the app will structure feedback to fall within the Living Building Challenge's seven petals: energy, water, site, materials, beauty, health, and equity, although we expect most feedback to center on beauty, health and equity. Feedback will be able to be spatially visualized in the app, as shown in the mock-up figure above. User demographic information will also be collected. Signage will be posted at the deployment site and across campus to promote engagement from all students, staff, and visitors. After the deployment, collected data will be analyzed and summarized to facilitate its incorporation into the building design.

2. CONNECTIONS TO THE LIVING BUILDING CHALLENGE

This pilot project has the potential to influence all Living Building Challenge petals, with perhaps the most substantial feedback on the more difficult to specify beauty, health and equity petals. This is a departure from a top-down approach, in which building designers may be disconnected from a project's end users. This research provides the space to empower all future building stakeholders to impact the building design and functions. The virtual experience not only informs heterogeneous populations of the building design, but

allows them to experience it. This deeper engagement with the project can increase the amount of feedback collected and the quality of the recommendations, which can lead to a Living Building that meets the needs of its diverse community. In addition, feedback will be requested related to all seven petals to holistically inform the design.

3. OUR INTEREST IN THE LIVING BUILDING CHALLENGE

This research will be conducted by members of the Network Dynamics Lab in the School of Civil and Environmental Engineering at Georgia Tech under the direction of PI (Prof. John E. Taylor) and in collaboration with Alissa Kingsley (the project architect) of Lord Aeck Sargent. Taylor has been participating on the Equity Petal Committee to represent Georgia Tech on the Living Building Challenge design. He and Kingsley were tasked with co-leading the implementation of an Equity Petal recommendation that the Living Building be welcoming to all visitors and be recognized as an exemplar for fostering equity on the Georgia Tech campus. We recognized that this is difficult to design in advance without broad input from a cross-section of stakeholders (e.g., students, faculty, staff & the local community). This Living Building Community Crowdsourcing application will enable gathering such feedback by crowdsourcing a conversation about the Living Building among the Georgia tech community that aims to capture and reflect the diversity of the community.

From a research perspective, one of the main objectives of my Lab is to develop feedback applications [e.g., 3] and study building occupant network dynamics [e.g., 4], aligning with the Living Building's goal of engineering spaces that are accessible on the human level. The proposed project builds on the Lab's virtual reality platform called CyberGRID (Cyber Enabled Global Research Infrastructure for Design) [e.g., 5] originally funded by the National Science Foundation (NSF). We anticipate this unique crowdsourcing application will lead to further opportunities for funding from NSF programs such as Cyber-Physical Systems, Cyber-Human Systems, and Smart and Connected Communities. We believe there is potential for novel insights to be gained from interrogation of the data we collect from a spatial perspective, being able to compare, contrast, aggregate and understand feedback based on its proximity to aspects of the model.

4. BENEFITS ANTICIPATED IN AREAS OF RESEARCH, TEACHING AND COMMUNITY ENGAGEMENT

Inclusivity is much easier to accomplish when proactively sought, and can be sustained if there is a commitment to it over time. Intentionally collecting building design feedback from future occupants will set the Living Building at Georgia Tech on the right path towards accessibility and inclusivity. The intended outcomes of this project are to engage Georgia Tech students and the local Atlanta community with the Living Building Challenge building and to inform the design of the building. Continuation of this feedback loop could be deployed during the construction and operations phases of the building to sustain connections between occupants and the building and show Georgia Tech's commitment towards creating inclusive spaces. Findings from the data will likely be broad, and be able to be applied across other buildings on campus or inform design standards. Development of such a system will contribute to the course agenda of the course *CEE4803F: Sustainable Cities* taught by the PI (John E. Taylor) in Fall 2017 at the School of Civil and Environmental Engineering, which examines the way cities are incorporating sustainability principles into their future design. Local community input into building design is vital to revitalizing cities in a sustainable and equitable way. This proposed pilot project creates an approach for engaging local communities to ensure the building functions best serve those who will use it.

References Cited

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BUDGET AND TIMELINE

We request a total of \$10,000 for 12 months to undertake the study described on the previous pages. The primary activity for the first 6 months will be development and testing of the interactive augmented reality viewer for the Living Building. We will begin collecting crowdsourced feedback as soon as the viewer is ready. This data collection will occur over a period of 2 months. The remaining period of the project duration will be focused on analysis of the data and development of recommendations for how the system can be implemented during the construction and operations of the Living Building to continue to maintain a “living” approach to adapting the building to the evolving needs of the diverse user base.

The above efforts require the following support:

Salaries. Two Computer Science and/or Civil and Environmental Engineering / Computational Science and Engineering students will participate in the front-end and back-end development of the interactive augmented reality viewer, respectively. The front end development will require refining the user interface, inserting the Living Building model at the correct location/orientation (using Simultaneous Localization and Mapping), and enabling the tagging interactivity. Back end development will entail setting up administrative access, data storage and usage analytics. For this effort we anticipate spending \$1,500/month in Summer and Fall for a period of 5 months (total \$7,500). Additionally, we will engage undergraduate students in the research to help with data collection on the project site one day per week in the Fall and Spring semesters (\$12/hr * 3 hourly undergrad workers * 4 hours = \$144/day; at 8 days = \$1,152).

Materials and Supplies. We are including \$1,000 to purchase an augmented reality software development kit (AR SDK) (e.g., Kudan) to support our AR development efforts. We are also reserving the remaining \$348 for any advertising (posters, flyers, other) that may be necessary to recruit a broad and diverse range of visitors to the site. Alissa Kingsley, the Project Architect at Lord Aeck Sargent, has agreed to provide a model of the Living Building to be used in the Interactive Augmented Reality Viewer.

Equipment. Our interactive augmented reality viewer will be downloadable as an iPad-only app. However, we do not wish to restrict feedback from those who own iPads. Therefore, we have spoken with the Library and we can borrow 3 iPads for 8 half days on the project site to solicit feedback of passers-by. We will also put up flyers and posters to encourage faculty, staff, students and the broader community to stop by and “visit” the Living Building and provide feedback using these iPads running our app.

	Year 1	TOTAL
<hr/>		
I. Salaries		
Students	\$8,652	\$8,652
II. Materials and Supplies		
AR SDK License	\$1,000	\$1,000
Posters/Flyers	\$348	\$348
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TOTAL PROJECT BUDGET		\$10,000

Biologically Inspired Sustainable Building Design Challenges for Middle School Engineers: Expanding the Educational Reach of the Living Building Challenge.

Project Description and Significance

In this pilot, CEISMC, in partnership with the Center for Biologically Inspired Design (CBID), will develop middle school lesson plans integrating sustainable building challenges with biologically inspired design methods. Situated in LBC data and design challenges, these lesson plans will be developed for and released to Georgia science and engineering teachers including schools with underrepresented populations in STEM fields. This pilot research on middle school education, will in turn support an NSF DRL (DRK-12) grant proposal to fully develop, deploy and test a three-year engineering sequence for Georgia middle school students.

The intersection of building and biology is fundamentally integrative. It represents an opportunity for students to make connections with designed and natural environments. These connections ground new knowledge to everyday experiences (buildings and nature), while wiring the learning across separate epistemic domains (architecture and biology). As part of a current NSF project, AMP-IT-UP (NSF #1238089), we demonstrated that middle school students enrolled for two semesters in integrative, multi-year engineering elective courses show significant gains in science and math learning, particularly at the foundational level, and show improvements in engagement, self-efficacy, and math and science interest and anxiety [1]. We theorize that in these courses, acts of designing and building (constructionism) activate embodied learning, enabling students to engage with the materials in deeper ways that yield significant, lasting increases in science and math learning.

Our proposed pilot project will employ one middle school science teacher, and one Georgia Tech undergraduate student from a relevant field (architecture, planning, biology, etc.) Using the LBC as a living laboratory, we will identify sustainable building challenges faced by the LBC and available supporting documentation (video footage, design documents, building plans, data generated by the building, expert interviews, etc.) We will also analyze student projects and materials collected from BID course at Georgia Tech that focused on sustainable building challenges. With our CBID partners, we will translate these materials into suitable middle school biologically inspired design challenges. Challenges will be synchronized to broadly coincide with grade-specific science learning objectives--for example while students in 8th grade learn about thermoregulation and energy in physical science, LBC lesson plans will focus on HVAC and energy issues in the LBC design challenge. Similarly, we will examine water issues in 6th grade (earth science), and natural materials in 7th grade (life science). Our science teacher and undergraduate student will develop standalone lesson plans and supporting materials tailored to each grade. These materials will be disseminated through an online sustainability teacher course that CEISMC developed in collaboration with the NSF Sustainability Research Network, to other teachers participating in CEISMC teacher development programs, and through CEISMC's website (more than 100 teachers total).

Both the undergraduate student and K-12 teacher will receive BID training and deeper knowledge of sustainable building challenges and solutions. In addition to creating and disseminating a unique set of lesson plans tightly coupled to the LBC and using BID methods,

this pilot will provide the foundation for a multi-million dollar, multi-year NSF DRK-12 grant. The LBC can also use the lesson plans for future educational outreach efforts.

Living Building Petals.

This pilot will disseminate actionable lesson plans and student materials using the LBC as the centerpiece for a multi-year STEM learning experience, targeted at low income and underrepresented youth throughout Georgia (equity petal). This includes distant rural populations that may otherwise not have access to, or even knowledge of, this one-of-a-kind building in the Southeast. This pilot immediately extends the reach of the LBC to as many as 100 teachers, many in rural schools or serving underrepresented populations. The proposed DRK-12 grant, to create a multi-year middle school curriculum, will further extend this reach.

Sustainable building materials (materials petal) and energy conservation (energy conservation petal) couple with 7th and 8th grade science learning goals and will be featured design challenges for their corresponding grade.

Lessons will be problem-driven, and therefore situated and supported through crafted narratives (narrative petal) featuring LBC design challenges, designer interviews, construction footage, etc. Ideally challenges will leverage the LBC as living laboratory, using historical data, live telemetry and live video feeds, delivered via the web to student classrooms.

LBC Connection Statement

The equity petal in the LBC documentation was particularly relevant to us. We believe that we at CEISMC are uniquely positioned to extend the presence and benefit of the LBC into communities that might otherwise be difficult to reach. Through CEISMC's outreach and research programs, we have developed close ties to teachers around the state and we are deeply committed to improving education in those communities. Coupled with our credibility in the Georgia science education community, we can achieve broad and rapid impact. At CEISMC, we are also experts in helping teachers craft lessons rooted in culturally authentic practices that are relevant and engaging for our targeted communities.

CEISMC and CBID both have a strong history of delivering on large NSF educational grants. In the last 8 years CEISMC has led the **Science Learning Integrating Design, Engineering and Robotics (SLIDER)** DRK-12 project (\$3.5 million, NSF #0918618, 10/1/09-9/30/16), the **Advanced Manufacturing and Prototyping Integrated to Unlock Potential (AMP-IT-UP)** Math/Science Partnership project (\$7.3 million, NSF #1238089, 10/1/12-9/30/18), the **Culturally Authentic Practice to Advance Computational Thinking in Youth (CAPACiTY)** STEM+C project (\$2.5 million, NSF #1639946, 10/1/16-9/30/19), and is a major partner on the **EarSketch: An Authentic, Studio-Based STEAM Approach to High School Computing Education** DRK-12 project (\$2.2 million, NSF #1417835, 8/1/14-7/31/18). CBID has developed rich process and tools for supporting interdisciplinary BID education [2-4]. Coupled with the recent evidence of learning improvements from our integrative approach [1], we believe that this three-way partnership between the LBC, CBID and CEISMC is the right opportunity at the right time. It is our hope that this project can become a model for future outreach efforts to develop equitable access to the LBC to communities across the state of Georgia.

Timeline

Dates	Activities
May 2017	<ul style="list-style-type: none">Recruit Middle School STEM teacher and Undergraduate student to participate in programDesign student/teacher experience through meeting with CBID and LBC to organize tours of construction site, discussions with LBC committee, and interviews with architects and designers
June-July 2017	STEM teacher and Student will <ul style="list-style-type: none">Participate in training in Bio-Inspired Design, Problem-Based Learning and Curriculum DesignResearch design challenges from LBC, map challenges and content from LBC and CBID to Georgia Standards of Excellence and Next Generation Science StandardsComplete drafts of three LBC design challenge lessons (energy, water, and materials)
Fall 2017	<ul style="list-style-type: none">Review and edit lesson plans (in consultation with CBID)Disseminate lesson plans through CEISMC networksUse materials generated through project to develop DRK-12 grant for December 2017 Deadline

Budget

The teacher will be funded through CEISMC's GIFT program, a 7-week STEM summer internship program for teachers. The cost of the GIFT program is **\$5,100** for the teacher stipend, and **\$1,500** for the GIFT program administration expenses. The student will be funded through a summer undergraduate research program earning a stipend of **\$3000**. We budgeted \$400 for materials and supplies for development of lesson plans. **Total budget \$10,000.**

Deliverables

- A set of sustainable building challenges, translated for use in middle school science.
- A mapping between sustainable building challenges and Georgia Standards of Excellence (GSE) and Next Generation Science Standards (NGSS)
- A set of relevant biological sources of inspiration broken down and translated for middle school science
- Middle school problem-based engineering design lesson plans, focused on energy, water and/or materials.
- A teacher action implementation plan (a GIFT requirement).
- Materials will be used to support an NSF DRL (DRK-12) proposal, December 2017.

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Living Building Proposal: Documenting the effects of the living building on biological diversity and succession

Marc Weissburg and Emily Weigel
School of Biological Sciences

Project Narrative

We propose to examine biodiversity of plants and select animal groups prior to, and subsequent to, the construction of the living building (LB). We will characterize the natural community surrounding the building both quantitatively (i.e. biodiversity and species richness measurements) and qualitatively (species lists and dominant species) to determine the extent to which the surrounding environment recapitulates key communities and processes of the reference habitat. Data will be collected as part of a class project and will be ongoing in order to document long term patterns of growth and development of the surrounding community (succession). The educational activity will use the LB to discuss how the built environment can impact biodiversity and ecosystem function, and use the LB as a case study.

These activities align with several of the foundational principles (Petals) that guide LB development and construction: *Place* and *Beauty*. As described in the Living Building Standards 3.1, the intent of *Place* is to define “where it is acceptable for people to build, how to protect and restore a place once it has been developed”. This goal is based on understanding the local environmental context in which the building resides and the capacity of the building to not interfere with, if not augment, the surrounding ecosystem. Imperative 1 of this petal states that project teams must understand and document the local conditions, and the on-site landscape must display ecological properties consistent with the original (reference) habitat, specifically biological diversity and temporal change in species composition (succession).

Measurement of species diversity through time clearly document the effect of the building on key ecological processes important to supporting the aims of the *Place* petal. Biodiversity is critical to long-term ecological stability and function. The variety and abundance of species, all of which are interdependent, can be critically impacted by changes in their natural environment. Sustainable development strategies recognize the value of maintaining local biodiversity, but few projects systematically quantify the impact of their building on local biodiversity. Having data which directly supports sustainable construction can justify the widespread adoption of more ecologically-friendly buildings.

This proposal will also address building requirements stipulated under the petal *Beauty*, which is designed to foster a greater human appreciation for, and human connection with, the natural world. Imperative 20 specifies interpretative signage and educational materials describing the goals and impacts of the living building. Our proposal includes using the information on biodiversity and temporal change we obtain to emphasize how the building has a positive impact. The final product will be a case study on the living building for K12 and college education in ecology and environmental sciences. The case study will examine the negative effects of the built environment on species and ecosystems, and show how the approach of the living building challenge results in urban designs that can coexist in a mutually positive relationship with nature. The ongoing nature of this effort assures that we can continue to tell the story of how the living building positively impacts biological infrastructure.

This proposal directly engages undergraduate students to collect the data initially and going forward. This will occur in the context of a core Biology course, Ecology (Biol 2335) that is required for all biology students. This course is taught every semester by either Weissburg or Weigel; Weissburg currently is scheduled to teach this class in Fall 2017 and Spring 2018, with Weigel coordinating the labs. The living building constitutes an important opportunity to engage students in project based, real world applications of knowledge. Using the living building as a case study allows students to see the societal relevance of their knowledge, the potential consequences of urbanization, and exposes them to critical concepts in sustainability. The opportunities afforded by using the living building as a biodiversity case study align with the core educational missions in the School of Biological Sciences.

Biodiversity measurements are taken using grid or other survey methods which are appropriate for beginning undergraduate students. We will focus on plant and insects because these taxa are the most numerous and easiest to quantify. However, we will encourage students to pursue independent research through existing mechanisms (Honors Thesis, student project labs, PURA etc.) to examine other groups or extent the project in other directions. We anticipate that this project, once started, can be a focal point for other ecological research that capitalizes on the Living Building.

We will develop an inquiry-based, multi-week laboratory unit to examine how biodiversity is affected by the Living Building. The module will focus on urban ecology to cover fundamental concepts in ecology, how the urban environment affects ecological processes, and the specific strategies that can be employed to ameliorate these potentially harmful effects to yield more resilient and sustainable human infrastructure. Comparisons to other campus or local urban areas will facilitate identifying the specific impacts of the Living Building. Products will include a short video on these subjects suitable for lay audiences and students from middle school to beginning undergraduates that will feature the work done by the Ecology Lab to document the effects of the Living Building. This will be produced by student teams (e.g. from digital media) in conjunction with the institute's Office of Communication. The project will produce specialized curricular materials (including a short video lecture) suitable for undergraduate courses in ecology, environmental science, and urban planning. We anticipate disseminating our data and materials through national organizations, such as the Ecological Society of America's EcoED education website. These materials will also reside on a GT website designed by GT students (e.g. industrial design or digital media) that highlights the role of the Living Building in fostering biodiversity.

These activities set the stage for larger efforts, such as novel educational proposals at all levels, including informal science education. This work also sets the stage for efforts to examine city scale resilience by mapping biological diversity within cities and understanding drivers and corrective strategies. This aligns with efforts such as the 100 Resilient Cities, but also local groups such as Concrete Jungle, which maps local biological components in order to increase access to food and other natural resources to promote social justice and equity.

Project Time Line

May-July 2017 – Develop lab project narrative and curricular materials incorporating biodiversity and urban ecology

August 2017 - Initial measurements (Biol 2335; Fall 2017)

October 2017- Construction begins

November 2017- Take second set of measurements (Biol 2335; Fall 2017)

January-April 2018 – website design and implementation; interpretative signage development; video narrative designed and produced

March 2018- Third set of measurements (Biol 2335; Spring 2018)

June 2018- Fourth set of measurements (Biology 2335; or independent student project)

May-July 2018

August 2018 – Fifth set of measurements

December 2018- construction completed

January 2019-ongoing – measurements taken at least once per semester by students in Ecology (typically August; March; June)

Budget

\$4,500 – roughly 3 weeks release time/summer salary for Dr. Weigel to assemble curricular materials

\$1,500 – Undergraduate student RA for videography and post production of video narrative (roughly 10 hours per week for one semester, which will support up to 2 students)

\$1,500 – Undergraduate student RA for website development (roughly 10 hours per week for one semester, which will support up to 2 students)

\$1,500 – Travel to one national meeting to present living building curricula (e.g. National Association of Biology Teachers or Ecological Society of America Annual meeting)

\$500 – misc supplies (digital media, preparation of curricular materials, etc)

\$9,500 - Total Project Budget

Pilot Project Proposal: Advancing Academic and Research Efforts Connected to The Living Building at Georgia Tech

Project Topic: The Living Building Equity Champions

Project Lead: Center for Student Diversity and Inclusion

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Project Summary: The Living Building Equity Champions (LBECs) are students charged with fully engaging in the development and realization of the **Equity Petal**. Aligning with **Recommendation #1 (Engage Underrepresented Groups on Campus In Building Design)**, the LBECs will work closely with the Center for Student Diversity and Inclusion (CSDI), whose mission is “to provide programmatic and thought leadership, expertise, and advocacy to continue to promote the Institute’s diverse student initiatives, programs, and efforts that facilitate our collective goal of student diversity and inclusion.”

From May 2017 through May 2018, a pilot group of 5-10 undergraduate and graduate students will serve as the Living Building Equity Champions, providing input and feedback to the design and development of the Living Building, engaging current students in the Living Building’s equity, sustainability and diversity efforts and connecting access to the Living Building with the greater Atlanta community, particularly K-12 students.

The intended outcomes of this project are for the Living Building Equity Champions to become fully knowledgeable of the purpose of The Living Building and fully-integrated stakeholders in this design process. We also expect an increased level of understanding among underrepresented minority students and community members as to the relevance and importance of equity within sustainability.

The LBECs will meet monthly to receive updates and provide constructive feedback to the design team. During the first six months, they will be exposed to the other petals and realize the deeper connections to equity initiatives. The second six months will include training for the LBECs in outreach and marketing to current students and K-12 students, particularly those from underrepresented communities.

The LBECs will also organize fall and spring lectures, bringing a speaker who is familiar with working with diverse communities and has expertise in equity and sustainability work.

Lastly, LBECs will begin planning for equity-related programs and initiatives to be housed in The Living Building, including, but not limited to: establishing an equity resource center, creating an equity visitors guide for The Living Building, profiling underrepresented leaders

in equity and sustainability, utilizing sustainable foods for meals from diverse backgrounds, and exploring professional development opportunities that align with sustainability efforts.

The Center for Student Diversity and Inclusion connects diverse students, faculty, staff, alumni, and community stakeholders in programmatic and research opportunities across disciplines to improve student performance and outcomes related to Georgia Tech's strategic plan. We hope to strengthen these efforts through the development of The Living Building Equity Champions.

Project Evaluation: There is a dearth of research that examines underrepresented group perceptions of sustainability programming in higher education. Georgia Tech's location and commitment to diversity and inclusion provide the ideal location for research that examines the factors that contribute to inequity in representation of sustainability research and praxis. Through the evaluation process, the Living Building Equity Champions pilot project will provide the opportunity for data gathering and program evaluation, and inform research and policy, as it relates to underrepresented groups and sustainability education and outreach. The evaluation process will consist of pre and post surveys, and semi-structured interviews that will be completed at the end of the pilot. The pre and post surveys will address the utility of the pilot and its components. They will also attempt to address expectations and efficacy, as they relate to the sustainable building and sustainability at Georgia Tech. They will solicit recommendations for improving the pilot and sustaining the efforts of the program. The semi-structured interviews will provide qualitative data that can speak to the pilot's impact on the lives of participants and their peers. This information will lay the foundation for future programs and research.

Pilot Project Proposal: Advancing Academic and Research Efforts Connected to The Living Building at Georgia Tech

Project Topic: The Living Building Equity Champions

Project Lead: Center for Student Diversity and Inclusion

Timeline

Date	Action
May 2017	Student application and selection process
June and July 2017	Planning meetings with students and design team (in person and web-based)
August 2017 – December 2017	Student meetings, fall lecture
January 2018 – May 2018	Student trainings, spring lecture
May 2018	Present project report and next steps in preparation for fall opening

Budget – Funding Amount Requested: \$10,000

Amount	Item
\$500	LBEC polo shirts and other recognition items (pins, bags, etc.)
\$1,000	Refreshments for 10 LBEC meetings
\$1,000	Office materials (paper, pen, printing, etc.)
\$1,000	Fall and Spring LBEC Lectures marketing materials, A/V, room fees
\$1,500	Fall and Spring LBEC Lectures refreshments
\$2,000	Equity-related learning materials for students (books, courses, webinars etc.)
\$3,000	Fall and Spring LBEC Lectures speaker honoraria

Georgia Tech Digital Building Laboratory

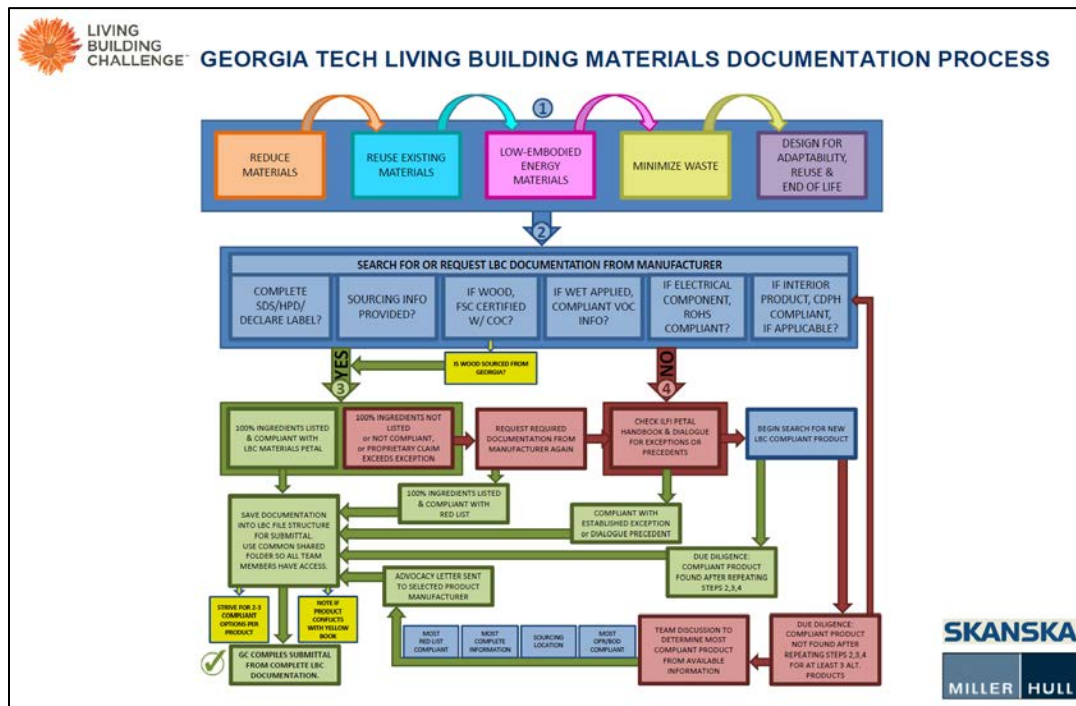
Workflows and Data Modeling in Support of the Material Sourcing Requirement of the Living Building Challenge

Russell Gentry and Dennis Sheldon

14 April 2017

One of the major impediments to implementing the Living Building Challenge is the requirement to document the materials used in the project – and to screen these materials for hazardous substances found on the Red List. The AEC (Architecture, Engineering, Construction) industry has not organized itself in any meaningful way to address this challenge, because the data that describes building material constituents and production processes are non-existent, held to be proprietary and thus not reported, or are provided without a consistent structure. The architects and engineers designing LBC buildings are thus constrained to a few poor options: using materials with a Declare label; completing extensive materials research and making decisions that often require expertise outside of their domain knowledge; or specifying generic products which essentially transfers the materials-screening requirements to the building contractor.

The Georgia Tech LBC team has developed a comprehensive process for identifying and screening materials (depicted below). The process and the data that underpins it are, in a large sense, ad hoc. The team and data have been organized for this one project, and when the project is complete, the team will disband and the data will disappear. The mission of the Digital Building Laboratory (DBL) has been to build and document data models and AEC information processes that are durable and universal. The LBC at Georgia Tech is a tremendous opportunity to match our domain knowledge in data systems and interoperability to the problem of ultra-green buildings.



This proposed project will develop a data model for capturing and reporting information regarding the materials requirements in the LBC. The project team will work with Jimmy Mitchell and Oliver Smith at Skanska to implement the data model on the Georgia Tech LBC building. An intern, likely an MS student in the Digital Building Lab, will work with Skanska this summer to observe and document the current process used by Skanska to screen the materials and assemblies to be used in the LBC. We will propose a neutral data model for this material screening information, and an interface to link this data to Skanska's Building Information Model. The summer intern will present her work in a fall graduate class at Tech: *Building Systems and Data*, being developed by Gentry and Sheldon, which is slated to be a core requirement in our expanding MS degree program in Design Computation.

The LBC provides us with a unique opportunity to leverage BIM data management processes in conjunction with other data systems including materials databases, sensors and construction management tools to create a best-in-class example of the potential for low environmental impact building construction and operations.

Key tasks of this data management project include:

1. Establishing model management and application procedures to leverage the green-building information in the project models across project design, planning, construction and operations activities,
2. Developing proof of concept integrations of the LBC data with other candidate systems to be used on the project, including planning, construction management, materials tracking, data visualization and building controls,
3. Providing focused development around tracking of environmentally sensitive materials, assemblies and compounds,
4. Developing publications and communications materials documenting and championing the project participants' activities to Georgia Tech and the broader AEC community.

We note that your RFP encourages proposals that touch on one or more petals of the LBC. Clearly, our proposal is firmly focused on the materials petal. We argue however that in our domain (architecture), the materials represent the entire embodiment of the designed object, and that all of the other petals are ultimately described by and achieved through the selection and organization of the materials that will ultimately become the assemblies that ultimately will become the LBC building at Georgia Tech.

Budget and Narrative

The majority of the funds requested will be used to support a summer intern, who will split her time between the DBL and Skanska’s offices in Atlanta. Skanska’s material screening efforts are being led by staff in their Charlotte office. Therefore, a travel budget for the student intern and one of the supervising faculty (Gentry or Shelden as available) is included in the budget. Finally, we anticipate implementing a database, which can be attached to a BIM model, as a proof-of-concept of the work and to use in our fall course. We therefore request a small stipend for the staff or graduate student that has this expertise (either a DBL research engineer or CS student).

LBC Red List Data Project	
Proposed Budget	
Student Intern @ \$15 / hour	\$ 5,400
Database Support	\$ 1,500
Travel	\$ 2,500
Total	\$ 9,400