

THE CAMPUS AS A LIVING LABORATORY

Using the Built Environment to Revitalize College Education

A GUIDE FOR COMMUNITY COLLEGES



ACKNOWLEDGMENTS



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The Center for Green Schools at the U.S. Green Building Council is making sure every student has the opportunity to attend a green school within this generation. From kindergarten to college and beyond, the Center works directly with staff, teachers, faculty, students, administrators, elected officials and communities to drive the transformation of all schools into sustainable places to live and learn, work and play. www.centerforgreenschools.org

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ABOUT THIS GUIDE

As community colleges redesign and retrofit campuses in greener ways, many forward-thinking institutions are using these projects as hands-on learning opportunities for students. These so-called “living laboratories” merge academics and campus facilities management to provide students with real-world skills and, for the institution, a path to meet its sustainability goals.

This guide is designed for community college personnel who are interested in launching or advancing effective living laboratory models on their campuses. Faculty, sustainability officers, and facilities staff, in particular, will find the information, best practices, and links useful.

ABOUT SEED

AACC’s SEED Center helps build the capacity of community colleges in educating for and building a sustainable economy. For more information about building campus living laboratories or to get connected to college leaders at the institutions highlighted in this guide, please contact sustainability@aacc.nche.edu or visit www.theseedcenter.org.

TABLE OF CONTENTS

1. Introduction	5
2. Eight Elements to Building a Living Lab	9
• Element 1: Engage the right campus participants	
• Element 2: Identify key collegiate programs	
• Element 3: Build credibility through engagement and data	
• Element 4: Integrate it into the curriculum	
• Element 5: Expand beyond individual programs of study	
• Element 6: Build partnerships with industry	
• Element 7: Engage support beyond the campus	
• Element 8: Open your labs to the community	
3. Conclusion	22
4. Appendix: Resources.....	23
5. Endnotes	24

INTRODUCTION

Over the past decade, St. Clair County Community College (SC4) in Michigan has transformed its 25-acre campus into a sustainable “living laboratory.” Green roofs dot the tops of buildings, a bioswale cleans tens of thousands of gallons of rainwater, and solar panels, wind turbines, and a geothermal field generate energy to power computer labs and other facilities. These green projects serve a dual purpose: to reduce the college’s carbon footprint and provide students with critical real-world, hands-on learning opportunities.

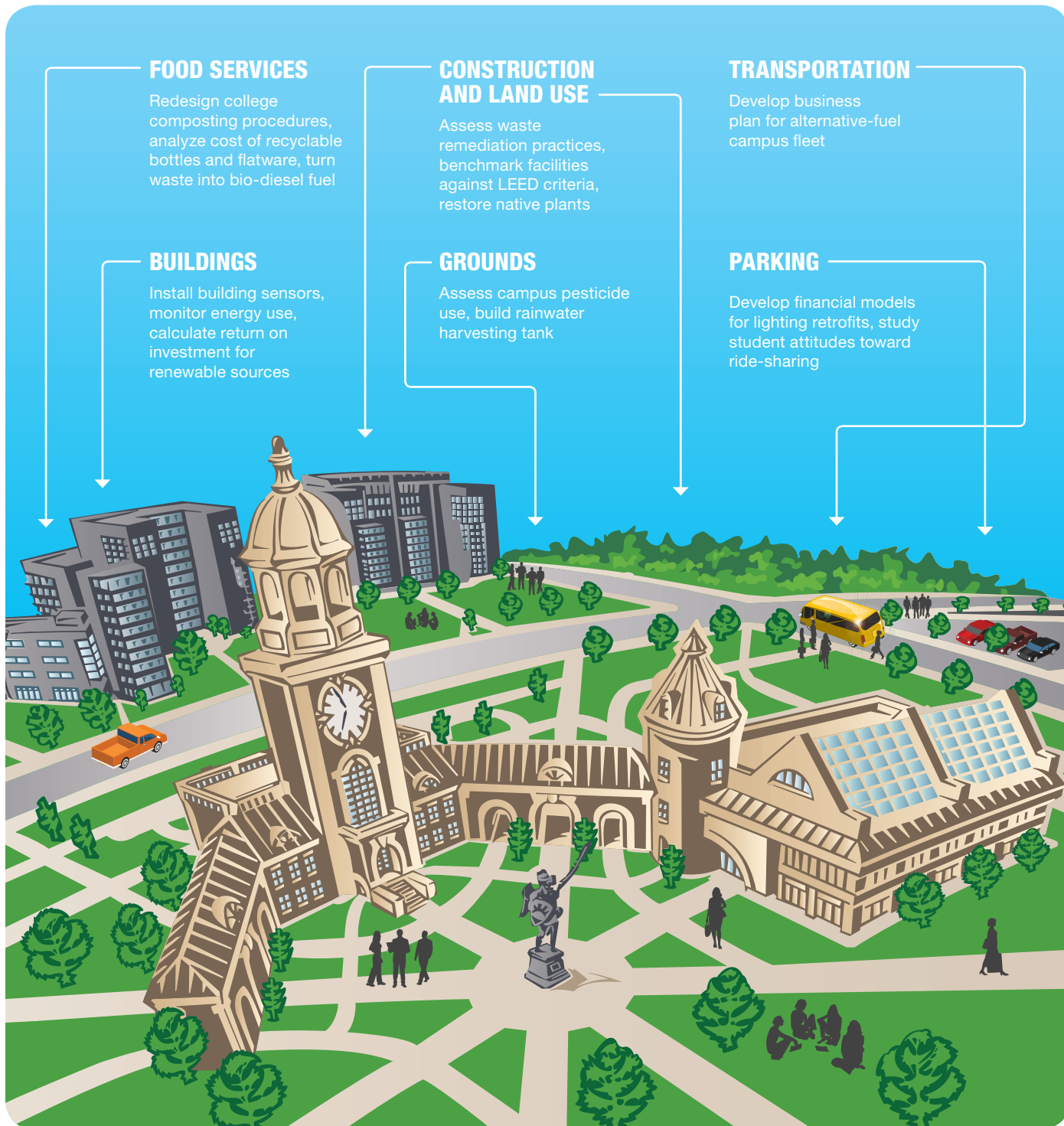
The installations are accessible to students and faculty to research, repair, and in some cases, take apart and reinstall. For SC4, this is being done in conjunction with traditional classroom learning to make instruction more relevant to students who are pursuing careers in clean technology sectors or simply have a passion for addressing sustainability and climate change.

The opportunity for wider adoption of these living laboratories across community colleges is vast. Most colleges do not consider experiential learning opportunities as part of regular facilities improvement strategies, and sustainability-focused course projects are often employed only by faculty in environmental programs.

It will require careful planning and collaboration—especially between facilities staff and faculty—for more colleges to develop these living laboratories in a way that maximizes all students’ learning experiences and yields benefits for the college’s bottom line. This guide highlights eight essential elements to building effective campus-wide living labs. It tackles some of the biggest challenges in these efforts, from breaking down internal institutional silos to addressing student safety to engaging industry. There is no single path to implementing living labs, but interviews with leaders of the most successful institutions revealed these common elements.

THE CAMPUS AS A LIVING LABORATORY

The campus facilities provide an array of dynamic sustainability learning opportunities for students across academic and technical programs.



WHY CAMPUS LIVING LABS? A Vehicle for the 21st Century Community College

Increasing enrollment, decreasing budgets, aging infrastructure, and pressure to improve student completion rates are pushing community college leaders to re-examine how they allocate resources, deliver curriculum, and keep students on campus and engaged. Living labs that couple academic rigor with applied learning on sustainability-related campus infrastructure projects provide an opportunity for community colleges to address many of these objectives simultaneously. Specifically, living labs can:

1. Facilitate experiential learning and make curricula relevant

It's well documented that experiential education—in particular, through hands-on, project-based learning—facilitates student success.^{i,iii,iii} When students are able to practice concepts learned in the classroom, they are more engaged, comprehend material better, and develop skills desired by employers.^{iv} More than three-quarters of community college students, however, say they have not participated in experiential education as part of a course, and only 13% of faculty require it.^v

Using the campus built environment to educate for sustainability lends itself perfectly to this pedagogical approach. Classroom instruction centered on creating healthier ecosystems, social systems, and economies¹ is inherently multidisciplinary and can be supplemented with enticing project learning experiences found across any college campus.

At Alfred State College (NY), applied technology students master math skills as they calculate energy flow from their campus' [net-zero model home](#). “To determine how to optimize the home's small wind energy source for maximum efficiency, for example, students are using algebra, geometry,

¹ These elements are referred to as sustainability's triple bottom line: assessing financial, social, and environmental impacts of corporate and institutional decision making.

and basic math,” said Craig Clark, dean. “But because the learning is contextualized within exciting projects—saving home energy and conserving resources—it's so much more interesting for them.”

Living lab experiences also enable students across college programs to understand the interdependence of local sustainability challenges (e.g., how more efficient campus landscaping can reduce water usage, which will lower a college's utility bills, conserve community resources, and produce more climate-resilient regions). This understanding helps students become more than just skilled workers; they become better consumers, homeowners, and change agents who can move communities to become models of sustainability.

2. Reduce the carbon footprint

Through initiatives like the [American College & University Presidents' Climate Commitment](#), hundreds of community colleges are pursuing climate neutrality in campus operations. Engaging students and faculty in the process through living lab educational experiences can help institutions reach this goal more quickly. For example, when Georgia Piedmont Technical College's (GPTC's) building automation students tracked patterns in the college's heating and cooling system use, they noticed that both systems often ran simultaneously and at times when no one was on campus. The students' recommendations—to specify scheduling changes and sub-meter facilities—saved the college hundreds of thousands of dollars in energy costs and have made a significant dent in the institution's greenhouse gas emissions.

Green Spaces and Student Productivity

- 80% of institutions of higher education have conducted at least some green retrofits and operational improvements
- 63% of these institutions report that these spaces have improved student productivity and test scores

Reference: 2013 McGraw-Hill report: *New and Retrofit Schools: The Cost Benefits and Influence of a Green School on its Occupants*

3. Use institutional resources efficiently

It's a simple case of institutional resource management: New labs are costly and community colleges have depleted coffers. Why not leverage a college's existing facilities or new green installations for use as the labs themselves? Colleges spend nearly \$10 billion a year on building construction and renovation^{vi} (and these projects are increasingly green).^{vii} "It occurred to me that between our older and newer energy-efficient buildings, we had every conceivable mechanical and electrical system right here on campus," said Tom Donovan, SC4's director of physical plant. SC4's newer buildings incorporate highly complex energy monitoring and controls that provide abundant data about real-time building performance. "Through these technologies, we're creating not only energy savings for the college, but also lesson plans for students on important topics like building automation and energy efficiency."

4. Improve college completion

The living lab model can support colleges in their efforts to create pathways to college completion. At Gateway Technical College (WI), the initial campus living lab work with Trane allowed students to learn on the college's new energy-efficient HVAC system and resulted in a dynamic workforce partnership. "The project work with Trane allowed our instructors to better understand needed skill sets and hone HVAC training for in-demand, clean technology occupations," said Dr. Bryan Albrecht, president of Gateway. "This, in turn, has led to the development of coherent career pathways in engineering and, ultimately, more students leaving with industry-recognized credentials and jobs."



Students help to install solar panels atop Alfred State's net-zero model home.

EIGHT ELEMENTS TO BUILDING A LIVING LAB

Based on feedback from community colleges actively implementing living laboratory pedagogy in their curriculum, the following eight elements emerged as key components for successful adoption. The elements are not linear or prescriptive, but provide a framework to assist colleges in adding facilities-based, experiential learning opportunities on their campuses.

ELEMENT 1: Engage the right campus participants

Successful integration of a living laboratory curriculum hinges on the active involvement of a number of key campus stakeholders. At their core, living labs bring together facilities staff and faculty—two groups that rarely interact—to study the campus infrastructure and make improvements. Asked about the facilities/faculty divide, one college director of technical education commented that he had been teaching energy efficiency for 20 years and had never even met the campus' energy manager.

The living lab experience doesn't work without this relationship. The facilities director holds the key (often literally) to improving institutional energy efficiency and making campus facilities accessible laboratories for faculty to develop sustainability learning. Understanding the facilities world—and making facilities directors feel comfortable that the projects will be safe and well-defined—is crucial.

Building a dedicated group of academic leaders, trustees, operational staff, and students will also help transform the living lab from a single-course project to a strategic initiative that supports the college's broader sustainability priorities.

Living Lab Initiatives: Key College Participants

Instructor: Those who have an understanding of and passion for sustainability concepts and are eager to create project-based learning experiences.

Division chair: Critical for prioritizing resource requests related to experiential activities.

Academic dean or vice president of academic affairs: Important for promoting living lab pedagogy across the institution and engaging faculty from relevant programs.

Facilities director: Will work with faculty to identify opportunities and ultimately approve student access to facilities and grounds.

Human resources director: Engagement will help to resolve student liability—a critical early barrier.



GPTC's Starnes Center, where the college's living lab initiatives began.

UNDERSTANDING AND COMMUNICATING WITH YOUR FACILITIES DIRECTOR

COMMON FACILITIES DIRECTOR CONCERNS	MESSAGING THAT WORKS
<p>Campus building systems are highly complex and dangerous—not the place for students.</p>	<p>Many living lab projects (e.g., energy audits, cost-benefit analyses of solar panels) require only minimal direct access to equipment for students. Those projects that do require special access (e.g., students to climb on roofs) will include direct oversight by faculty or facilities staff.</p>
<p>We're understaffed. Now I have to oversee students working on this?</p>	<p>Student projects can actually relieve some important workload items—such as campus waste inventories and equipment logging and tracking—and can provide better data and success stories to the administration and community.</p>
<p>Our budget is too tight.</p>	<p>Living lab projects can build internal capacity with untapped resources (e.g., students). They are also designed to deeply engage corporations, which can mean an influx of technical assistance, equipment, and other donations that support facility operations.</p>
<p>Sounds great, but I operate in “reactive mode” and spend my time responding to emergency hot and cold calls, water leaks, and equipment malfunctions.</p>	<p>Living lab projects tend to attract the attention of college leaders and the media and often, as a result, more resources for creative ideas. This can allow for more time to think proactively and strategically about energy savings and campus resource conservation.</p>

SUCCESS STORY:

Gearing Up

GEORGIA PIEDMONT TECHNICAL COLLEGE
(DeKalb County, GA)

After some preliminary successes, Georgia Piedmont Technical College (GPTC) building automation and refrigeration faculty decided to embark on a more formalized living lab effort with input from a campus-wide committee. Instructors met with the vice president of academic affairs, the department chair, the human resources manager, the academic dean, the college's financial officer, and the facilities director. The instructors presented the benefits of living laboratory pedagogy, including better student retention of concepts, improved communication and team-building skills, applied and independent learning, and improved analytical skills. Two key concerns raised by the committee were student liability and the potential disruption of normal building operations, including the risk of students breaking expensive equipment.

In response to the committee's concerns, the instructors created a plan detailing a set of stipulations to be put into place before the projects commenced:

- All work would start with a small building (29,000 square feet).
- Student work would be clearly documented and defined within the course materials and would be required as a graded component, much like a traditional lab.
- The work would have to support either course or institutional student learning outcomes.
- All living laboratory experiences would have to be supervised by faculty and coordinated with the facilities director.
- A safety course would be a prerequisite to student participation.

The committee, and later the president, approved the plan. These early meetings with key decision-makers laid an important foundation to create buy-in, allay fears, and set clear deliverables and measurable outcomes.

ELEMENT 2: Identify key collegiate programs

Hands-on, applied education is generally associated with technical training, but there also are many opportunities to incorporate living labs into academic programs. The items at right are examples of program areas well-suited to living laboratory integration:



In coordination with Gateway's grounds team, a student in the horticulture program uses natural techniques to enrich soil on the Kenosha campus.

Academic Programs

Agriculture: sustainable farming practices, nutrient cycling, erosion control, pollution management, assessing campus guidelines and sustainable materials to use for water, pesticide, and nutrient management

Business and Accounting: business case for college-wide green purchasing policies and for sustainable facilities retrofits, cost analysis, simple payback and return on investment calculations, full-cost accounting

Engineering: campus building energy audits, energy modeling to optimize building renovations, heat transfer through composite walls, designing renewable energies applications (see also the [U.S Environmental Protection Agency's green engineering library](#))

Environmental Science: campus carbon footprint measurement, greenhouse gas emissions inventory, facility waste management

Physics: solar radiation effects, heat and mass transfer, unit conversions, gas inventories

Psychology: sustainability awareness and education influencing student behavior toward energy efficiency

Technical Programs

Building Automation: facility historical log analysis, building scheduling and occupancy monitoring

CAD: building shell and construction drawings, building information modeling

Construction: existing campus stormwater filtering and waste remediation practices (see also [USGBC's Hands-On LEED: Guiding College Student Engagement](#) for specific LEED-related student activities)

Electrical: branch and feeder circuit location, code violation identification, building electrical consumption tracking, identification of peak demand charges

Green-Related Technical Programs: rainwater harvesting product design, solar photovoltaics installation, alternative fuel research

HVAC: inventory and location of mechanical systems, heat gain calculation, efficiency analyses, preventive maintenance

Industrial Maintenance: campus preventive maintenance program assessment

For more information on projects within any of these disciplines, see the appendix of resources.

Examples:

Agricultural Programs:

Gateway Technical College's associate degree program in [horticulture](#) teaches students about sustainable plant production, including limiting the use of chemicals, growing in compostable pots, and using organically based fertilizers. Students work with the college's buildings and grounds team to incorporate these practices into the campus landscaping efforts, starting with the space around the college's child care center.

HVAC and Industrial Programs:

Forty-five Davidson County Community College (NC) HVAC and industrial design students installed a heat pump with one of the highest energy-efficiency ratings and an energy recovery ventilator that allows for more homeowner control of ventilation into their green-home campus renovation project. The home now houses international students.

Business and Innovation Programs:

Students at Indian River State College's (FL) 65,000-square-foot LEED Silver [Brown Center for Innovation and Entrepreneurship](#) regularly analyze the building's energy tracking monitors to understand distributed power generation and use. Students use that information to compare the types of vertical wind turbines and solar panels that power much of the facility and how much energy they produce. They also use the information to understand how weather patterns such as heavy air, sun intensity, and wind affect air-conditioning use and solar electricity production.

ELEMENT 3: Build credibility through engagement and data

As with any initiative to manage institutional change, early wins are essential to build momentum. Best-practice colleges have focused on these early indicators to demonstrate success and build interest among a wider audience:

Documenting energy and utility savings through student involvement: When **Georgia Piedmont Technical College's** (GPTC's) building automation faculty and students documented the hundreds of thousands of dollars of potential savings from some simple scheduling changes, their work became a convincing argument for a full campus living lab initiative. "Once we realized that there were dollars to be saved, everyone became very intrigued," said the former facilities director. "Senior leadership buy-in after that was really pretty simple."

Engaging the right partners: Forming partnerships was a key element in the creation of **Milwaukee Area Technical College's** (MATC's) 32-acre, 540 kW [solar photovoltaic educational lab](#). The college brought in more than 30 entities, including Johnson Controls, the Midwest Renewable Energy Association, and Milwaukee Public Schools, to design the

project to meet energy and job training objectives. "Having diverse and influential players in the room was important to ensure that the project ultimately serves a range of constituent needs," said Dr. Michael Burke, president of MATC. "Critically, it also brought a level of excitement that convinced our board that resources were being well-spent."

Measuring student outcomes: Conducting student assessments before and after the living lab projects is critical. At GPTC, instructors assess students at both intervals on their technical skills (reading blueprints and engineering drawings) and interpersonal skills (communication and teamwork). The assessments enable the instructors to continually improve the experience for students and demonstrate to senior leadership that the living lab is a worthy investment.

Bringing money to the table: **Johnson County Community College** (KS) faculty and students approached the facilities department with \$400,000 (generated through the students' own initiated "green fee") and an idea to equip campus buildings with building sensors. The students' money was used to purchase the sensors, which the facilities department agreed to install. Students across various programs are now using the sensors as part of class assignments to monitor building performance.



A St. Clair County Community College engineering professor explains to his students the design features of one of the college's green roofs.

SUCCESS STORY:

Engaging Facilities Staff in the Classroom

BY TOM DONOVAN, PHYSICAL PLANT DIRECTOR,
ST. CLAIR COUNTY COMMUNITY COLLEGE

I regularly lecture in our college's alternative energy classes and take the students to our warehouse to see the front-end building automation system work in real time. It is very exciting to see the reactions of the students. Many cannot believe that such a system exists and that you can control an entire building from one computer. As the system continually adjusts temperature settings in a remote room, for example, the students start to see how the concepts they learned in class play out.

For me personally, it is a wonderful added part of the job to teach. Sometimes I get questions from students that I've never thought about before.

The key to all of this is the relationship I have with the faculty. We've moved beyond regularly scheduled living lab planning meetings and now we email one another to discuss different classroom exercise ideas or articles about emerging clean technologies. All of the speed bumps we encountered early on are long gone, and it's just become part our culture.

ELEMENT 4: Integrate it into the curriculum

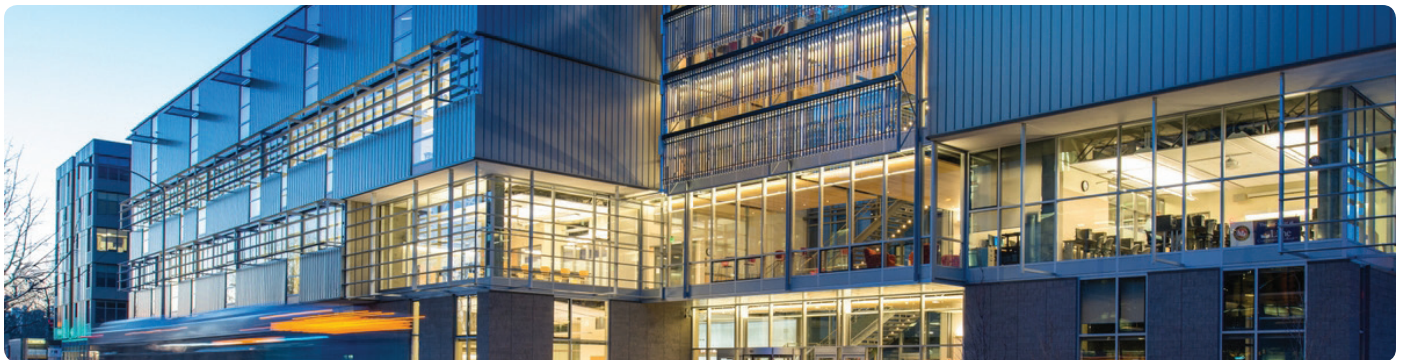
Incorporating effective living laboratory exercises into the curriculum requires creativity and careful planning by the instructional staff.

Instructors should find ways to connect the course's student learning outcomes (SLOs) to learning projects involving campus buildings or grounds. For example, a physics course could include a project in which students calculate annual incident solar radiation absorption at a certain location on campus. The project could be enhanced by asking students how much energy could be reasonably captured annually with solar arrays at the location and how many tons of greenhouse gases would be eliminated. This project would support several physics SLOs related to energy, reflectivity, incident angle of radiation, and absorption. For specific classroom resources and examples, see links in the appendix.

Explicit instructions are critical to even simple living laboratory experiences. The syllabus should include topics related to the experience and handouts should incorporate at minimum:

- A full description of the project, including the topic's connection to the college's broader sustainability goals, if they exist
- Student learning outcomes
- Where and when the work will take place
- Expectations for on-site behavior
- Safety issues to keep in mind
- Student work expectations

Lane Community College's new LEED Platinum downtown campus.



SUCCESS STORY:

How Living Laboratory Pedagogy Can Be Effectively Used Across the Curriculum

LANE COMMUNITY COLLEGE (Eugene, OR)

In the first year of the college's associate degree program in energy management technician training, all students take courses to ensure that they have a strong technical understanding of building construction and operations. Classes focus on how the building shell, HVAC, lighting, and systems affect energy efficiency. Students pursuing concentrations such as renewable energy learn how to choose, size, and install renewable energy systems for photovoltaic and solar domestic hot-water systems.

To reinforce the concepts of energy efficiency, each year students study a building on campus or in the community. Built in 1965, the campus provides an array of opportunities to analyze older building systems to determine how to improve energy efficiency of existing facilities. Under the supervision of a faculty member, students conduct energy, water, and lighting audits and log data at the facilities. Students prepare formal technical reports that include results of the audits, evaluation of the data, simple payback calculations, and a life-cycle cost analysis. The reports are presented to the facilities department and include

potential improvements to energy efficiency. In some cases, the measures may have few or no budget implications, and others may require a comprehensive, long-range implementation plan.

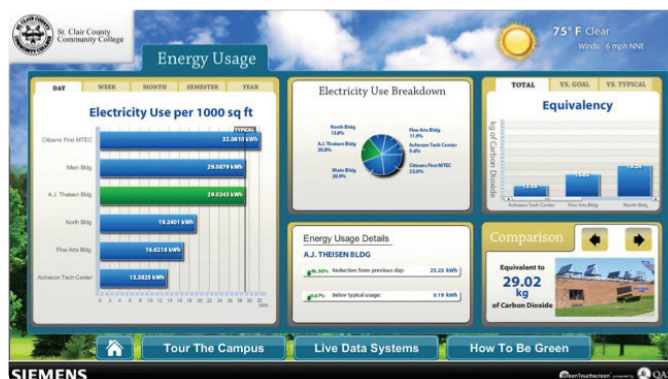


Lane Community College students set up data loggers to monitor building efficiency. Each logger must be configured with the right sensor type and information for a specific installation location.

In December 2012, the college opened the [Downtown Center](#) to house the energy and water education programs. The building is LEED Platinum and showcases the latest in green building design, construction, and operations. From the earliest design phases, faculty have used the building's shell, five comfort systems, and light lab as tools to prepare students for careers in the new green economy.

Leveraging LEED on Campus Through Student Participation

The LEED green building rating system can serve as a tool to facilitate project-based learning opportunities for students and can support efforts to transform the campus into a living laboratory. Whether through a course, internship, or volunteer opportunity, students can research LEED credits, assess their impact on buildings, conduct energy and water audits, develop and implement recycling programs, administer building-occupant and transportation surveys, and facilitate design charrettes. Learn more at USBG's [Center for Green Schools](#).



St. Clair County Community College's real-time green touch screen allows students to monitor campus energy usage from an accessible campus kiosk. The information is also available online for an external audience.

ELEMENT 5: Expand beyond individual programs of study

Instructors who are new to sustainability-focused, project-based learning should begin with small projects within a single course. As instructors gain experience, they can begin to broaden their project scope by collaborating with other

faculty and staff on interdisciplinary projects, exposing students to the inherent synergies of sustainability (and shedding light on the range of clean-technology professions). Interdisciplinary projects like this will build students' systems-thinking skills—a core competency desired by companies in these industries.

SUCCESS STORY:

Cross-Disciplinary Living Lab Initiative

GEORGIA PIEDMONT TECHNICAL COLLEGE

When GPTC's living lab initiative became interdisciplinary, students' retention of core concepts improved (as measured by course assessments), and companies involved in the effort (including large building automation companies and smaller technology contracting firms) hired many of the graduating students.

Living lab projects at GPTC began to spill over into new buildings and program areas. The Starnes Center for adult education was selected for an interdisciplinary pilot project because it was close to the main campus, was relatively small (less than 30,000 square feet), lacked accurate floor plans, and was extremely inefficient (it had no central control system and so heating and cooling systems ran continuously). Instructors from accounting, HVAC, building automation, drafting, engineering, and green technologies formed a project design team, designed the project elements for each student group, and defined the parameters for collaboration between the groups.

The accounting students formed a hypothetical company responsible for "greening" the Starnes Center. They obtained quotes from mock subcontracting firms comprised of student teams from each major, with accounting students acting as the general contractor and other student teams as subcontractors. The instructors played the role of building owner. All interactions were patterned on real-world practices, and students received technical training on the products and technologies from a faculty and industry team.

The project's outputs included:

- Energy models in eQuest software
- 3-D rendering of the facility
- Scale drawings of the building
- Comprehensive project proposals in professional format
- Energy conservation proposals
- Automation system design proposal and drawings
- Sustainable technologies systems proposals with ROI calculations
- HVAC systems inventory and load calculations
- Business plan

At the end of the semester, students presented these products and plans to the college's facilities department and a panel of industry representatives. Students will now help to design, install, and monitor the approved energy conservation measures at the Starnes Center. In addition, the college is moving forward with plans to replicate this student-led work at other buildings across GPTC's campus.

GPTC Cross-Disciplinary Living Lab: Project Team (Student) Responsibilities

Accounting: overall project management, cost analysis, proposals to building owner

Air-Conditioning: HVAC systems inventory, efficiency assessments, heat gain/loss calculations

Building Automation: automation system assessment, design, installation

Drafting: scale drawing of building in AutoCAD

Engineering: Level III Energy Audit with eQuest modeling and energy conservation measures recommendations

Green Technologies: proposals for rainwater harvesting, solar array, solar thermal heating



GPTC students install a communications network to track building conditions as a required, graded component of their course work. Both students have since graduated and are project managers at two building control companies in the region.

Living Labs as a Bridge From Noncredit to Credit

The living lab model can serve as a vehicle to bridge noncredit programming in clean technology to credit-based degrees. For a stand-alone, noncredit course developed quickly in response to a perceived need, collaborating with corporations and credit-based instructors on a living lab can bring the attention and support needed to justify a related program for credit. Alternatively, the effort can expose faculty to the connection between programs leading to better integrated curricula. At one college, the living lab laid a foundation to integrate a noncredit solar photovoltaics course, which was at risk for elimination, into an existing HVAC associate degree program. Through the integration, the college is able to continue its important renewable energy instruction.



A building automation student mounts a sensor in GPTC's Green Technologies Academy.

ELEMENT 6: Build partnerships with industry

Most successful campus-based living laboratory projects are conducted with industry partners. Businesses ranging from lumber companies to commercial cleaners to solar panel manufacturers to food services will naturally be hired to implement green- or sustainability-related projects on campus. Companies like these, however, are also showing an interest in leveraging their equipment and services to support student learning.



St. Clair County Community College students use data loggers to measure and analyze water temperatures as part of the new Siemens solar-powered hot water system in the college's Acheson Technology Center.

SUCCESS STORY:

Energy Service Companies (ESCOs) as Partners

SIEMENS AND ST. CLAIR COUNTY COMMUNITY COLLEGE (Port Huron, MI)

ESCOs like Siemens Industry, Inc., Trane, and Johnson Controls, Inc., provide colleges a comprehensive set of energy efficiency, renewable energy, and distributed generation services. These partnerships often yield benefits beyond efficiency savings.

Siemens and St. Clair County Community College have worked together for more than 10 years to build a comprehensive campus sustainability initiative. Siemens helped SC4 conceptualize its campus living lab and has served as a single point of contact to implement a range of renovations and retrofits. Almost all of them serve as educational opportunities, including:

- A new building automation system with tagged, labeled, and color-coded piping and wiring to help students and faculty understand how the pieces of

the new energy-efficient HVAC system work together and flow through the college's main mechanical room

- A window wall for students to view the new equipment
- A kiosk that shows temperature, flow rates, and other data to allow observers to see the building automation system in action and understand how the building's comfort is controlled
- A donated wind turbine accessible to students and faculty

Siemens also worked with SC4 faculty and administrators to add courses on energy analysis of commercial buildings and facility management, and planned a site visit for SC4 faculty at Lane Community College's nationally recognized AAS program in energy management to support implementation of the new coursework.

"Siemens recognizes that deep relationships with campus partners mean supporting experiential learning opportunities for students and staff that leverage complex technology and facility infrastructure improvement projects," said Charles Cohen, building technologies sustainability education director.

"Most important, students who have been trained on these living labs, solving real sustainability problems, no doubt have the hard and soft skills that are urgently needed in our industry."

-Siemens executive

SUCCESS STORIES:

Living Lab Internships and Co-ops

MERCED COLLEGE (Merced, CA) AND HONEYWELL INTERNATIONAL, INC.

As part of a campus energy retrofit, Merced College partnered with Honeywell and local subcontractors to launch an enhanced college curriculum focused on teaching conservation strategies using the building upgrades as case studies. Students across programs now use the school's energy statistics in a series of structured classroom assignments that help them understand how technology and behavior change can affect a building's performance.

Honeywell has since hired two students as paid interns, including Joe Newman, within Merced's engineering math and science department. Under the guidance of the company and the department's dean, Newman is responsible for developing energy management reports for Merced's facilities department. He also leveraged the campus excitement from the living lab assignments to launch a Honeywell-sponsored recycling program. "The internship was a real eye-opening experience," said Newman. "It was a way to connect the theoretical knowledge with practical skills and see how major campus construction projects actually get done."

LANE COMMUNITY COLLEGE AND LOCAL UTILITIES

Lane Community College's energy management program includes a co-op requirement that provides students with relevant field experience that integrates theory and practice while providing opportunities to develop skills, explore career options, and network with professionals and employers in the field. The program has organized co-ops at many organizations and companies, including the local utility and an architectural firm. Through these co-ops, students learn to conduct energy audits, log data, and administer lighting surveys.



Students install a 1 kW solar PV system on the Lane Community College science building roof.

ELEMENT 7: Engage support beyond the campus

Don't have any suitable projects on your campus? Try finding one in your community. Communities across the country are undertaking sustainability efforts that range from fuel-efficient public transportation systems to the adoption of new green-building codes. Colleges can integrate living lab projects into courses using these off-campus opportunities.

“One of the best places to conduct off-campus energy audits [as part of an internship process] is at public buildings,” said Roger Ebbage, a faculty member at Lane Community College. “Elementary schools, middle schools, and libraries, in particular, often cannot afford to hire a professional energy services firm to conduct an energy, water, or light audit.” Final assignments for Lane's energy management students include a report to the school district or city identifying opportunities to save energy including a cost-benefit analysis of different system solutions.

SUCCESS STORY:

Community Colleges and Habitat for Humanity

YAVAPAI COLLEGE (Prescott, AZ)

Arizona's first net-zero energy house was built as a cooperative effort between [Yavapai College's residential building technology \(RBT\) program](#) and its local Habitat for Humanity affiliate. Green features of the building include a water-managed foundation, airtight frame construction, high-performance windows, solar hot water, and photovoltaic panels. The house was designed to meet the standards of several national green-building rating systems and won five awards, including an Energy Value Housing Award from the National Association of Home Builders Research Center. The project supported RBT learning outcomes, including mastering energy-saving strategies and technologies.

USGBC Student Group

The USGBC Students program is a national initiative of the Center for Green Schools that equips college students with tools and resources to transform their campuses, communities, and careers. Members of USGBC Students integrate sustainability themes into their coursework and advocate for green university practices and policies on campus. Contact studentgroups@usgbc.org to learn more about starting a student group at your school.



Yavapai College's residential building technology students complete work on a neighborhood Habitat for Humanity green home.

ELEMENT 8: Open your labs to the community

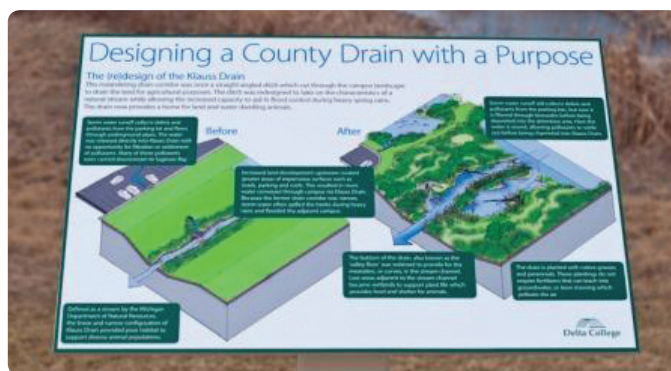
Effective campus living laboratories have an impact beyond the student body. If designed and promoted well, they can serve as a learning model for community members and enhance the college's reputation as a regional sustainability leader (which, in turn, can drive more prospective student interest). Some of the innovative ways that colleges are generating community excitement about their living lab work include:

Tours and field trips: Alfred State College conducts regular tours of its campus [green demonstration home](#) that students designed and built. Labor unions, K-12 students and teachers, community-based organizations, and interested homeowners are taken through the building to see the green construction and supporting technology, including a monitoring and control system screen in the entryway that shows the home's real-time energy consumption trends.

Signage: To draw attention to the sustainability efforts on campus, Delta College (MI) developed signs with a landscape architecture firm to identify and explain green features to campus visitors and students. The signs for the new sustainable stormwater management system, for example, highlight the redesigned watercourse, natural filtration system, and habitat restoration.

Web presence: Davidson County Community College captured its 1,000-square-foot green home renovation project in a series of YouTube videos referenced on its college sustainability page. The series allows the viewer to see how students progressed and completed the building.

Workshops: Continuing education classes, workshops, or lectures incorporating the college's living laboratory projects can enhance the college's reputation. Butte College (CA), [the nation's first grid-positive college](#), conducts regular workshops for homeowners and business leaders on topics such as green home and business facility improvements, energy and utility bill savings, and landscape design for water reduction and wastewater reuse. Different parts of the campus are used as demonstration projects.



Delta College's sustainability awareness signs, found at various green campus locations, are used in conjunction with classroom learning and independent study.



Lane Community College's building engineer leads a tour of the new health and wellness building for the public to learn about energy-efficient designs in lighting and space.

CONCLUSION

Living laboratories can be a new paradigm for how community colleges promote student success and serve their communities. By creating these hands-on learning opportunities, colleges will be preparing students with the analytical, interpersonal, and technical skills required to succeed in a variety of careers from conventional green jobs to finance, farming, and construction management. Living labs can also instill in students the desire and ability to think critically about our most daunting sustainability challenges.

Our hope is that as more colleges follow the elements highlighted in this guide, these living laboratories will become a common core strategy for community colleges making the 21st century transformation.

For more information about building campus living laboratories, or [to get connected, formally, to a mentor](#) at one of the institutions highlighted in this guide, please contact sustainability@aacc.nche.edu or visit www.theseedcenter.org.

APPENDIX: RESOURCES

The following organizations provide resources specific to the design and execution of higher education living laboratories.

Advanced Technology Environmental and Energy Center (ATEEC)

www.ateec.org. ATEEC is a National Science Foundation Advanced Technological Education Center (ATE). The site has curricular materials for a range of clean technology fields.

American College & University President's Climate Commitment (ACUPCC)

www.presidentsclimatecommitment.org. Resources for designing, implementing, and financing living laboratory models. Well over 100 community colleges are signatories of the ACUPCC network, each submitting their own campus climate plans. As of the summer of 2013, 51 have reported a total of 54 completed green building projects and 49 have reported 696 completed energy efficiency projects. Descriptions and case studies of these activities are available for download.

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)

www.ashrae.org. Resources, events, and scholarships for colleges with engineering, HVAC, or building automation programs. ASHRAE local chapters work with community colleges to integrate sustainability practices into campus facilities maintenance and related curriculum.

Association for the Advancement of Sustainability in Higher Education (AASHE)

www.aashe.org. Resources, case studies, and guidelines for higher education institutions to implement sustainability initiatives including living lab models. See www.sustainabilityscience.org/files/StoriesfromtheField.pdf for specific living lab case studies.

Building Efficiency for a Sustainable Tomorrow (BEST)

www.bestcte.org. BEST is a National Science Foundation ATE Center focused on building automation and efficiency. BEST offers professional development and online resources for college educators.

Experiential Learning Center at Truckee Meadows Community College

www.learnpbl.com. Resources on and examples of experiential learning practices.

National Association of College and University Business Officers (NACUBO)

www.nacubo.org. Resources and professional development events for operational staff interested in integrating sustainability into campus operations.

National Council for Science and the Environment (NCSE)

www.ncseonline.org. Resources for deans and faculty teaching sustainability and environmental disciplines.

National Renewable Energy Laboratory (NREL)

www.nrel.gov/sustainable_nrel. U.S. Department of Energy site with education materials on a range of clean technology areas.

National Wildlife Federation (NWF)

www.nwf.org/Campus-Ecology.aspx. Reports and case studies of higher education institutions' sustainability efforts. Their Greenforce Initiative, with Jobs for the Future, supports a number of community college sustainability best practices.

Second Nature's Campus Green Builder

www.campusgreenbuilder.org. Campus carbon reduction resources and community of action for campus sustainability initiatives.

Sustainability Improves Student Learning (SISL)

www.serc.carleton.edu/sisl/index.html. A collaboration of academic associations dedicated to sustainability education. Includes classroom activities.

U.S. Department of Education Energy Efficiency and Renewable Energy

www1.eere.energy.gov/education/index.html. Resources on a range of clean technology industry sectors, including a section for educators.

U.S. Green Building Council (USGBC)

www.centerforgreenschools.org. Resources, case studies, and events for colleges that are incorporating LEED into their curriculum.

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