Stewards in the Classroom: Introducing Principles of Environmental Comfort and Control to Support Energy Conservation in Education Buildings

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Phase 1 Partners: students and faculty of the College of Architecture, Planning, and Design, BNIM Architects, Henderson Engineers, Lisa Shubert of APDesign.
Phase 2 Partners; K-12 School(s) and architects to be identified during Phase 1.

DESCRIPTION OF PROJECT

At the end of 2017, the United States Green Building Council (USGBC) announced the certification of the 2000th K-12 school within the widely-recognized Leadership in Energy and Environmental Design (LEED) Program. Interest in sustainably-designed schools comes from not only energy savings, but also from wide-ranging, measurable student health and performance benefits associated with natural light (Heschong Mahone Group 1999) and improved environmental quality (Tanner 2009, Barrett et al 2015). The flip side of sustainable buildings is that technology and controls, introduce a new level of complexity, versus conventional buildings, for building owners, managers, and users to navigate. While some level of operation is automated, a critical amount of control – via lighting and HVAC controls – is left in the hands of building occupants.

While everyone at some point learns how to manipulate a thermostat and light switches, the impact of this decision isn't obvious. How are these controls, and our expectations for physical comfort, linked to energy consumption or savings? As a society, this is an important gap in understanding that separates what we know about energy (and its costs) and how our decisions in buildings affect their operation. Buildings such as those certified in the LEED program are designed and recognized based on their *estimated* energy consumption, making assumptions about how the building will be operated by owners and users. How can designers and engineers know that users will understand how to efficiently 'live' in their buildings? Unfortunately, many communities of users aren't fully educated or empowered to optimally control their buildings. As green buildings become the status quo, occupants need to understand these foundational issues related comfort, controls, and energy.

The proposed project will engage communities on campus and off campus to develop an educational tool to educate building users about comfort and environmental controls in learning spaces such as classrooms and studios. The project will be organized into two phases and cooperation with facilities departments will be sought to compare energy consumption before and after educational tools are deployed. The first will engage the faculty and students of the College of Architecture, Planning, and Design, gathering user input and environmental data to develop a customized, multimodal educational tool for students, faculty, and staff in the college. The second phase of the project will engage one or multiple schools who, like APDesign, are occupying newly built green schools. The learning tools developed for APDesign will then be adapted to secondary school communities, where it may be adopted as a curricular component. A review of resources available to K-12 educators from the USGBC (https://learninglab.usgbc.org/) shows that no current resources exist that introduce a comfort- and control-based approach to environmental systems and building energy.

In summary, the project aims to help building occupants to understand the criteria affecting comfort in those spaces and better operate building controls. This knowledge should overall reinforce sustainable design goals in schools, ensuring energy is conserved while users better appreciate the quality of classroom environments.

Stewards in the Classroom: Why Teachers and Students are Important in Conserving Energy in Educational Buildings
Rather than focus solely on the technical aspect of systems, this project will focus on factors that directly link people with sustainability:

- The basic physics and physiology of thermal and lighting comfort
- How occupants can make decisions (with lights, thermostats, shades, clothing, etc.) to work with, rather than against, expectations for comfort
- The environmental impact of behaviors and decisions related to comfort and controls

These factors are behind self-reflective knowledge informing our perceptions, reactions, and moderations of our environment: far more useful than high-tech 'energy dashboards' that display real-time energy consumption and generation in many contemporary buildings. Green buildings work at their best when their occupants know how to

to support energy conservation with responsible behavior and decisions. For example, learning to adapt to cooler thermostat settings in winter has around a 3% impact on utility costs for every 1F in temperature reduction [DOE]. Shutting off lights in the daytime can reduce electricity consumption in a commercial building by 70% [LBNL]. Because buildings use so much energy in the United States (40% or greater) and lighting and HVAC energy are a large portion of that energy use (35% and 40% of building energy, respectively), comfort and controls can have a great impact on national energy consumption.

Nearly every student will eventually be a building owner or a building occupant whose decisions impact resource consumption in buildings. If a more complete understanding of comfort and control is critical to the operation of tomorrow's green buildings, then engaging students in this topic will ensure that this knowledge may have broad future impact in society.

Project Timeline and Activities

Phase 1: APDesign

The first phase of the project will engage the community of faculty and students of the College of Architecture, Planning, and Design, whose home is the recently renovated Seaton and Regnier Hall. The first phase will consist of the following activities:

Spring 2018	· Collect information on user satisfaction regarding their environment, along with what baseline knowledge (or assumptions) users have about the controls and systems.
Fall 2018:	· Students enrolled in ARCH413 (taught by the PI) will use environmental instrumentation (see resources section) to measure key parameters in the primary spaces in Seaton and Regnier Hall.
Fall 2018-Spring 2019	· Investigators and student assistants will use occupant feedback and observed data to develop a multimodal educational tool for using the building's lighting and HVAC controls, and provide these tools to the APDesign community. · The project will collect energy consumption data prior to and after the dissemination of the education tool, and compare results to evaluate potential impacts of user education on energy efficiency. · Potential partners schools will be identified for Phase 2. · A research plan for Phase 2 will be submitted and approved by the University Research Compliance Office prior to proceeding.

Phase 2: Partner School(s)

The second phase of the project will engage one or multiple partner K-12 schools. Schools will be selected based on the following criteria: recent construction or renovation of the school, feasibility to work with students and teachers in the middle or high school science curriculum of the school, and cooperation with the architecture firm responsible for the school design. The second phase of the project will consist of the following activities:

Fall 2019	· Identification of classrooms, students, and teachers. Meetings with architecture firm(s). · Data collection and interviewing students and teachers. Project assistants and students will be involved in data collection, using project instrumentation (see resources section). · Adaptation of Phase 1 educational tools for use by students and teachers in the partner school · Evaluation of educational tools based on feedback from students, teachers, and other collaborators.
Spring 2020	· Development of a universal Environmental Comfort and Control toolkit for widescale distribution. This toolkit will be an extension of the original educational tools developed in Phase 1, and will be shared via national channels (such as the USGBC Learning Lab and Center for Green Schools). The toolkit will describe specific resources, tools, and activities that can be used by teachers to integrate concepts/knowledge of the project in their courses, using the environment in their own classrooms as a teaching and learning tool.

Project Partners

Project partners for Phase 1 include the College of Architecture, Planning, and Design, the Kansas State University Facilities Department, BNIM Architects (architect of record or the Seaton Hall and Regnier Hall project), and Henderson Engineers (Mechanical, Electrical, and Plumbing engineers for the Seaton Hall and Regnier Hall project). Lisa Shubert of the College of Architecture, Planning, and Design will collaborate on the project during Phase 1.

Project partners for Phase 2 will be identified during Phase 1, using Phase 1 strategies and outcomes to develop partnerships with potential school districts and professional firms.

Proposed Project Outcomes and Impact

Initially, the project's tools and subsequent evaluation will contribute to the LEED certification of the Seaton/Regnier Hall project under Innovation in Design. Credit will be earned for the successful implementation of a "multifaceted green building education plan"; activities in this proposal would satisfy multiple criteria of this credit. Importantly, new knowledge and approaches emerging in the proposal will be shared through USGBC's public library of credits with other institutions working toward future LEED certifications. In other words, the project tools will be accessible to future architects, owners, institutions, and their constituent communities.

Beyond LEED certification, a central and important project's outcome will be the translation of the proposed educational tools to support K-12 educational curricula. Educating students affectively about green buildings adds to the many incentives schools have to pursue green projects. With schools spending 30-35% of their non-capital building expenses on utilities [State of Our Schools 2016], following through with the education of building occupants is important for schools that have invested in green buildings. Measuring building energy consumption before and after engagement with these educational tools is expected to show concrete outcomes of occupants with increased knowledge of comfort and control.

Moreover, introducing students to a comfort-based approach to building energy efficiency and sustainability will lay the foundations for increased stewardship of students' environments. Immediately, classrooms are environments where students relate and apply this knowledge; yet this knowledge also stands to hape the way these students inhabit their future living and working environments.

Environmental Factors and Metrics to be Evaluated

Ambient Air Temperature
Relative Humidity
Mean Radiant Temperature (MRT)
Operative Temperature
Clothing Insulation Level (CLO)
Ambient Air Velocity
Peripheral Skin Temperature
Visual Field and Task Area Geometry
Illumination Level
Luminous Emittance

Applicable Environmental Comfort Standards

ASHRAE Standard 55 Comfort Model
ASHRAE Adaptive Comfort Model
Illuminating Engineering Society Lighting Handbook, 10th edition – recommended illuminance and luminance ratios

Project Resources: resources listed below already in use by the principle investigator in ongoing teaching and research activities. This equipment is not part of the funding request.

- Non-contact Infrared Thermometers: for measuring average surface temperatures at a 1D point
- Infrared Cameras: for capturing 2D and live images of surface temperature
- Anemometers: for measuring ambient air speed
- Air temperature and humidity sensors
- Light meters: for measuring illuminance and luminous emittance

Funding Requested

Funding requested is detailed in the 'Budget and Budget Justification' section. The primary purpose of funding for the project will be to pay student research assistants for their time completing weekly tasks to support the project through both proposed phases. The principle investigator and partners will not receive compensation or other payment for their time, however the costs of travel in phase 2 is part of the proposed budget.