Training the Next Generation of Building Operators: Development of the Building Operators: Grid and Occupants (BOGO) Training

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ABSTRACT

Grid-interactive efficient buildings (GEB) are intended to be efficient, connected, smart, and flexible to distribute and/or shift loads. Most of these buildings use smart technologies such as Occupant-Centric Controls and Operation (OCC) to decrease energy use. Although OCC intends to maintain occupant comfort, frequently building inhabitants do not understand the controls or use controls incorrectly, which can lead to problems in operation. Building operators and occupants can get stuck in a loop of conflict, trying to find a way toward both energy efficiency and comfort.

Our team was funded by DOE to create a building operator training program to help operators understand some of these tricky communications and relationship-based issues with building occupants. The Building Operators: Grid and Occupant (BOGO) training aims to provide a human-centered approach to training the next generation of building operators in operating GEBs. In particular, this 14-hour curriculum, which expands upon the Smart Buildings Center's Building Operator Certification® (BOC) Fundamentals Program, will teach future operators how occupants can impact building energy use and operations, what to look for, how to communicate and build relationships with occupants, as well as strategies they can use to resolve both building and human-based problems to maximize energy efficiency. Students will see how occupant behaviors can impact the built environment and building energy performance: from occupant to building, to grid scales. In this paper, we provide an overview of the BOGO curriculum and discuss how the human dimension is critical for inclusion in building operator training and the overall success of GEBs.

Introduction and Context

Within the last decade, many energy-efficient solutions, such as energy storage, smart building technologies, and grid-interactive technologies, have been developed to decrease the nation's reliance on non-renewable energy resources. These technologies offer a tremendous opportunity to enhance national/international energy resilience and unlock untapped energy savings. If implemented at a large scale, additional cost and energy savings can be realized. However, if technologies grow more rapidly than the skillsets and knowledge of those who must adopt, install, and operate these measures, then it is unlikely that cost and energy savings will be fully achieved. In particular, grid-interactive efficient buildings (GEBs) can shed, shift, and modulate their load to provide added value to the grid at a levelized cost of energy (LCOE) less than all traditional and renewable sources (Neukomm et al. Dec. 2019), a $15B/year market opportunity (Procaccianti and NEEP Jan. 2020). There is significant savings potential, but only if these buildings are designed, operated, and used as intended.

Building operators — the personnel that manage and maintain building HVAC and building automation systems (BAS) in increasingly energy efficient buildings — are uniquely positioned to address facility energy consumption, operational costs, grid-interactivity, and occupant complaints due to discomfort.

Buildings interact with the grid in complex ways that vary over time and space, weather, occupants' use, and hidden conditions in the grid. It is not expected that building operators will be experts in all these areas, yet they should be able to effectively communicate and coordinate with such experts and the building's occupants. Trainees often rotate through various hands-on demonstrators such as refrigerant loops, wiring, and steam fitting which are important for learning tactile skills and understanding system interactions. However, no such demonstrator illustrates the important interactions between all the systems in a building (e.g., HVAC, BAS, building physics, the environment, and occupants), and their respective impact on energy consumption and load. In addition, these potential benefits require advanced controls, the operation of which is often outsourced to contractors that work with building operators, yet many building operators struggle to effectively work together and share responsibilities.

Further, to fully realize the $15B/year market opportunity of GEBs, it is critical to carefully design for the occupant experience and their interactions with the building. Through various forms of professional and secondary education, building operators and/or facility managers must stay apprised of these rapidly evolving DERs to maintain the necessary skills and credentials to properly manage and operate buildings.

A training program for operators of mid- and large-sized buildings to improve their GEB literacy is required which must also include content on maintaining the indoor environmental quality (IAQ) expectations of occupants, possibly through occupant-centric control (OCC) to ensure occupant satisfaction with GEB initiatives (Langevin 2019). Although OCC intends to maintain occupant comfort while minimizing energy use, frequently, building inhabitants do not understand the controls or use controls incorrectly, which can lead to problems in operation (Day and Gunderson 2015; Day 2015; Day and O'Brien 2017). Building operators and occupants can get stuck in a loop of conflict, trying to find a way toward both energy efficiency and comfort (Nagy et al. 2023; Ruiz et al. 2022; Day and Gunderson 2015; Day and O'Brien 2017).To be truly successful, operators must also have a firm grasp on the soft skills needed to relate to people in the building.

> *"Successfully incorporating OCC requires operators to enhance their expertise in advanced technology integration, effective communication, and educational strategies. However, like all paradigm shifts, fundamentally changing the role of operators will be met with several challenges. The first major challenge for operators will be balancing historical quantitative measurements such as standards, costs, and efficiency with modern qualitative measurements, including comfort, productivity, and happiness. To prepare for their future as OCC operators, both tenured and new operators will need adequate training on integrating technology, state-of-the-art communication methods, and educating occupants. Overcoming these existing knowledge gaps will foster healthy operator and occupant relationships critical to transitioning from traditionally managed buildings to OCC building" (Nagy et al. 2023)*

This paper provides context for the importance of building operator training that includes GEB, OCC, and soft skills. In the first section, workforce development needs are discussed. Next, we provide a summary of the benefit of fostering building operator and occupant relationships and the importance of occupant behaviors. Then the pedagogical approach is presented prior to the curriculum overview. The paper concludes with a discussion of the team's overall process, as well as a dialogue of the challenges our team has faced along the way.

Workforce Development: Training the Next Generation of Building Operators

Numerous accreditation entities, professional organizations, and associations offer education and training tools to further develop skillsets within building operations including BOMA, ASHRAE, ASHE, IFMA, APPA, AFCOM, Realcomm, IREC[1], and more. This list of organizations is not exhaustive, but it represents areas that may relate to both building operation and GEBs. One of the most prominent training avenues for operators is the Building Operator Certification® (BOC) program. The Smart Buildings Center administers the BOC and describes it as, "a national leading competency-based training and credentialing program for building engineers and maintenance personnel. Throughout the levels of training— Fundamentals of Energy Efficient Building Operations Certificate and Building Operator Certification Levels I and II—participants are taught how to make a building more comfortable and efficient by making its systems work better together and identifying low-cost and no-cost energy efficiency improvement opportunities" (Nicholson 2023).

Figure 1 provides a schematic overview of the building operator career development plan enabled by this project, and how such trained building operators will interact with the rest of the workforce necessary for grid-interactive efficient buildings.

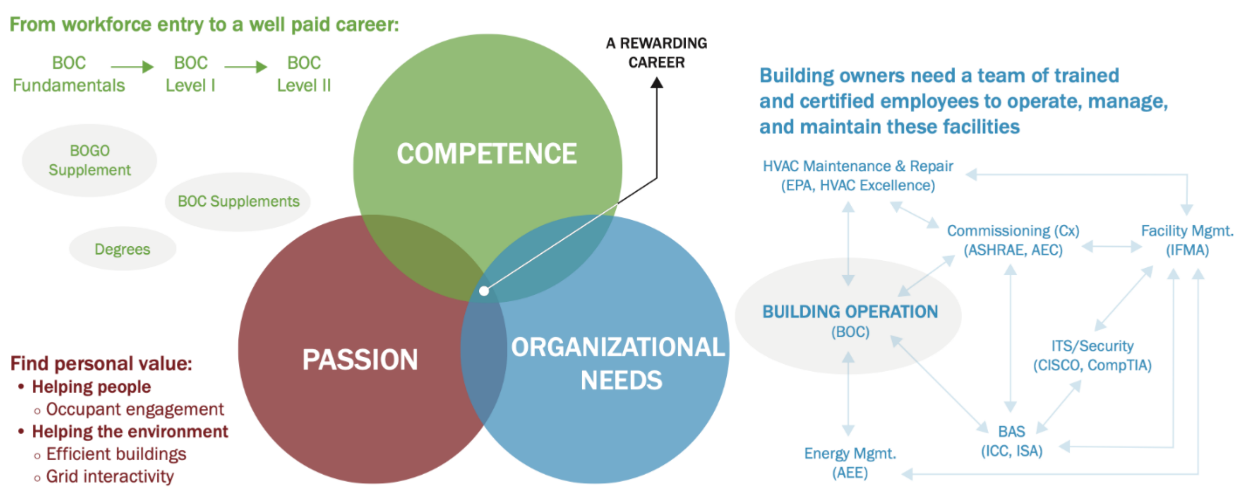

Figure 1. Building Operator Career Plan and Relationships.

To address issues with an aging workforce in building operations (Nicholson 2023), major changes in building technology, changing occupant expectations, while also promoting diversity in this workforce area, our team partnered with the BOC program to develop and deliver this new training and education program. The modules developed for this curriculum support the development of the new BOC Fundamentals program targeted at vocation technical (VoTech) high schools and community colleges (CCs), to fill the vacancies of this workforce that is growing 10% per year faster than the national labor market. Current BOC graduates help

[1] Building Owners and Managers Association (BOMA), American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), The American Society for Health Care Engineering (ASHE), International Facility Management Association (IFMA), Leadership in Educational Facilities (APPA), Association for Computer Operations Management (AFCOM)

their employers improve energy efficiency by 2-3% and cut operating costs by as much as $20,000 per year, yielding 93% participant satisfaction (Boston 2024; BOC 2020; Putnam and Mulak 2001). In general, efficiency is less than half the full potential value GEB. Add to that the value of satisfied occupants, and we hope to double the value of the current BOC training, resulting in payback periods of well less than a year. Through our targeted training, operators will learn about both GEBs and occupant-related issues such as communication and relationship-building — often overlooked topics in building operator training.

The BOC Program is currently offered in 42 states (with a business model for expansion to all 50 states). With the new BOGO curriculum being offered through the existing BOC training network as well as a standalone offering for career preparation, professional development, and transitional career advancement, the project team will be able to scale the training nationally. Building Potential has a wide network of partner utilities in the Western U.S., Midwest, Mid-Atlantic and Northeast who can also help deliver the standalone training to their customers and service providers, further expanding the reach of the BOGO curriculum. This training could be offered to community colleges, technical schools and other educational centers to their existing educational program portfolios as a way to offer additional certificates to their students entering the job market and to create a workforce river of needed trained operators to implement and maintain the new building technologies to increase energy efficient building operations and reduce the impact on the grid.

In the next section, the importance of understanding occupant behaviors and interactions – with both the building and the operator -- are discussed.

The problem with OCC: ***Is it pesky occupants or is it communication & education?***

One aspect of this project that is truly unique is the additional emphasis on occupants and the communication with them. If we want truly high performing buildings, the critical behavioral/occupant facet must be addressed. Facility personnel must be able to communicate with the occupants and be able to build relationships to fully understand the occupants needs and expectations of a space, but also to be able to successfully train the occupants and explain the functionality and intent of the various building technologies accessible to them.

As one simple example, there is an art and science to setting up vacancy sensors vs. occupancy sensors. Over-automation can lead to wasted energy and uncomfortable, annoyed occupants (who may even alter the sensors to regain control). To a great degree, these kinds of control decisions really influence the overall performance of a given building. It is necessary to find a balance between occupant control and building automation, i.e., what should truly be automated vs. what should not be automated? Early in the design process, it is important to establish how occupants can, should or should not interact with the space (e.g., light switches and opening windows).

Many owners/designers/technologists may over-automate controls and DER technologies in buildings. In some of these instances, controls may be unknowingly hijacked by occupants, creating building operation issues (Day and O'Brien 2017). If we can provide effective training and education to all parties involved in DERs and GEBs: including building officials, owners, operators, and occupants– as a holistic system – we may be able to better rely on occupants to play key role in reducing overall building energy use. From a technical standpoint, this may enable a reduction in unnecessary complexity in the control systems that ultimately make these systems more fragile, less robust, and more difficult to maintain. In addition, occupants' building interactions can be critical in understanding time of use behaviors, etc. that impact the grid and energy decisions. Ultimately, there are many target audiences that must be engaged through a holistic system of training to adequately increase the adoption of GEBs.

In addition to needing to understand complex systems, the new age of building operators also needs to understand how to communicate with occupants. We have all heard of thermostat wars. People want to take control of their buildings, and in the long run, if not done carefully, this can lead to discomfort, broken or disabled controls and bad blood between occupants and operators (Day and O'Brien 2017).

To mitigate negative environmental impacts when occupants do not have control (and find ways to get the comfort they want at the expense of the building performance, its energy goals, and sometimes other building occupants), building operators must balance the offering and management of occupant autonomy. When occupant control is removed via installation of automated sensors, timers, and the removal of creature comforts, especially without direct and clear explanation from "the powers that be" with the building/facility operations, occupants will find a way to make do or hold the grudge of discomfort. It is the operator's job to manage occupant expectations and complaints to avoid contempt and strife between parties and meet performance metric goals.

Occupants and their behaviors are impactful to the total energy consumed in a building, regardless of its level of energy performance when compared to state-of-the-art buildings or building type. Improving the relationships between operators and occupants will be increasingly necessary as buildings become more grid-interactive and intelligently controlled to manage and balance electrical demand. Having well-established relationships and channels of communication with building occupants helps building operators manage everyone's expectations in the building while also learning more about how certain areas of a building differ and be prepared with solutions for occupants.

Effective feedback and communication skills are needed to maintain the two-way relationship between occupants and operators, whether that feedback is good or bad. Operators often only hear about problems, and they are not regularly reminded when the building environment is satisfactory to its occupants. Frequent and informal opportunities to measure occupant satisfaction goes a long way, but formal in-depth occupant surveys and observations are still recommended when looking to understand the impacts that occupants have on the building performance or energy goals of a building. When feedback is provided, operators need a certain level of information to address complaints, and "training" building occupants to interact with an operator, training occupants to understand how and why a building works the way it does and training an operator how to interact with occupants properly (clearly, de-jargonized, and frequently) is just as important. Operators with better feedback mechanisms and direct communication with the occupants of their buildings could better manage complaints and comfort challenges with confidence (Ruiz et al. 2022).

There is a need for effective communication between building users and operators to establish trust, reliance, and understanding from occupants. This goes for all sorts of situations, but especially when an occupant has a problem or complaint and needs to get it resolved but may not know where to start or the actual source of the problem. Transparency (and recognition) in the operator's understanding of the problem and effective communication back and forth between the operator and occupant will help make sure everyone is on the same page about an issue or situation. The optimal relationship between operators and occupants may look like this:

- Providing education or insights on how the building works, and insights into why occupants may be having specific issues.
    - Operators may also offer examples to occupants directly, with guidance on what to do, and what to expect in the building – especially with new technologies.
- Clear and frequent communication on need-to-know operational information, things to look out for or be aware of, and especially when handling user complaints about the building's environment.
- Occupants should know where to go or look for information regarding several common issues. That might be a complaint portal/website, a tenant representative, the operator's office, or the phone number to reach the operators/managers.
    - They know how to find/contact the operator if it's an uncommon or one-off issue.
    - They know what to do in case of facility emergencies.
- More than one person per floor or occupant knows all the above or at least anything about how the building works (Ruiz et al. 2022).

When an operator does not communicate and build relationships with the occupants they can feel out of control, unheard, or left in the dark about facility operational decisions or energy-saving methods or rationale. Through targeted education and training, we can bridge this gap.

Learning and Pedagogy Framework

Before diving into the curriculum, it is critical to address how this training is different than other existing programs. Through literature and experience, we know that lecture formats alone do not suffice when it comes to truly understanding the complexities of mechanical, electrical, and plumbing (MEP) systems in buildings. Oftentimes, students require hands-on experiences, field trips, and in-depth projects to fully grasp these intricate concepts.

To maximize learning outcomes, we have rooted our teaching approach in two key pedagogical perspectives: experiential learning and the *Interactive, Constructive, Active, and Passive* (ICAP) framework. These approaches have informed the curriculum development.

Experiential Learning. Kolb (Kolb 1984; Kolb 2009) theorized that the learning process could be enhanced through interactive behaviors and experiences as "...knowledge is continuously derived from and tested out in the experiences of the learner." Kolb's learning cycle is iterative in that the learner reflects on a concrete experience, makes conclusions, plans a further experiment that again provides a concrete experience. Further, three factors that may increase the transfer of learning are: 1) the first learning experience, 2) motivation, and 3) the context of learning. For the initial learning experience, students need to understand the material as opposed to memorization (Bransford, National Research Council . Committee on Developments in the Science of, and National Research Council . Committee on Learning Research and Educational 2000). Experiential approaches can be especially beneficial to learning, as they cater to individual differences (Gosen and Washbush 2004).

Interactive, Constructive, Active, and Passive (ICAP) framework. ICAP predicts that as students become more engaged with learning materials, from passive (receiving lectures without an opportunity to be engaged) to active (manipulating) to constructive (generating) to interactive (dialoging; co-creating), their learning will increase (I>C>A>P) (Chi and Wylie 2014; Chi et al. 2018).

So, what did we actually do?

To address the gaps identified above, our project team developed Building Operator: Grid-Occupant (BOGO) training modules to expand the training of entry-level building operators beyond a focus on energy efficiency and peak demand reductions, to include energy flexibility. This BOGO training is unique and innovative in that it builds on the industry-leading BOC curriculum and introduces scalable, entry-level modules focused on energy flexibility, GEBs, and IAQ maintenance strategies including OCC.

This standalone curriculum provides advanced career preparation for secondary students and a clear career advancement pathway for post-secondary students, established facilities professionals, and displaced or underserved professionals across the U.S. Completion of the BOGO training will provide greater access to apprenticeship programs, entry-level jobs, and additional industry education and training opportunities, including but not limited to BOC Fundamentals of Energy Efficient Building Operations, BOC Level I, and the Massachusetts Clean Energy Vocational Internship Program (Center 2023b). The BOGO curriculum addresses a critical industry need for building operator proficiency in these subjects and combined with the growing GEB markets, presents a significant workforce development opportunity.

Overview of the Curriculum

The goal of this project was to develop, test, refine, and disseminate a robust education experience and training modules for entry-level building operators. Our project team created a curriculum, i.e., BOGO training modules, to expand the training of entry-level building operators beyond a focus on energy efficiency and peak demand reductions, to include energy flexibility. The curriculum includes content on maintaining the indoor environmental quality expectations of occupants, which may necessitate OCC, as well as guidance on behaviors and interactions between occupants and the buildings. Further, there is a focus on how operators can build relationships with the tenants or occupants to maximize both occupant and energy use outcomes.

Delivery of Training

The iterative process of developing this curriculum included two phases in the classroom: a feasibility study with five students and a small-scale pilot with 20 students. The BOGO curriculum is intended to be delivered shortly after students complete the BOC Fundamentals of Energy Efficient Building Operation (FEEBO) training. The Boston area was selected as the initial testbed for this project due to favorable support for clean energy and automation by local and state (Center 2023a, b) governments, a population eager for entry-level training in technical vocations, and the facilities management program at Madison Park VoTech school, which was seeking new curriculum at the time of the proposed work. Their interest in BOGO was part of a broader effort by the school to include industry-recognized certifications (i.e., OSHA-10) into their curriculum. Our team has refined the curriculum iteratively alongside implementation and testing, in addition to the invaluable guidance of our curated Industry Advisory Board (IAB).

The goal of the feasibility study was to understand the target audience and ensure the curriculum materials were presented at an appropriate level. The academic year schedule and the project schedule did not allow for the entire FEEBO and BOGO curriculum to be taught, so only FEEBO was taught at Madison Park in the first phase from January through June 2023. A group of six students began the program, taught during a 90-minute extra study periods by a Madison

Park facilities teacher, and four students took the final exam and passed. The authors trained the instructor on teaching the FEEBO curriculum and periodically assisted the instructor in the classroom, gaining valuable insights into the challenges encountered in the classroom.

After assessing FEEBO in the classroom, at the end of the academic year, the BOGO curriculum was to be assessed in an online synchronous classroom. Six students were recruited for this online BOGO feasibility study from a list of students who completed the FEEBO program online. Most individuals were early in their career as a building operator or similar position, not yet eligible with the two years of experience to enroll in the BOC Level I course. The six lessons of BOGO, plus a review and final exam, were held during four weekly 4-hour sessions. Only two students completed this program. The assessments before and after each session provided insights into the different challenges between in-person and online classrooms. The training was delivered by the project team, including the authors of this paper and additional subject matter experts. The sessions were interactive, incorporating real-time Q&A, breakout discussions, and virtual demonstrations of building automation systems (BAS).

The second phase was a small-scale pilot with 20 students in both the FEEBO and BOGO curriculum at Madison Park in the 2023/2024 academic year. This was taught to the full class of students during the first 60-90 minutes of their regular class time, by the same instructor from the previous year. The instructor would guide the students in a round-robin reading content from the handbooks accompanying the slides and lead them through the walkthrough, case studies, and building operations emulator activities.

Pedagogical Approach

To increase learning, especially in this particular group and demographic, the project team used the ICAP framework for each of the training modules. Through this approach, as students become more engaged with learning materials, from passive (lectures) to active (manipulating, in simulation) to constructive (generating) to interactive (*co-creating*), their learning will increase (I>C>A>P). We used this framework to inform the curriculum and overall activities. For instance, within each lesson, a variety of activities and teaching techniques were employed to ensure students would have a well-rounded understanding of each topic, including the following components:

- **Case Studies**: Learn about specific building operation strategies in real buildings.
- **Building Walkthroughs**: Observe and learn from walkthroughs in real buildings.
- **Building Operator Emulator**: Interact with a building automation system in a simulated building.
- **Breakout Discussions**: Engage students in active discussions to understand key concepts.
- **Lecture and Slides**: Used to deliver much of the teaching content.
- **Pre- and Post-assessments**: Measure the students' self-reported baseline knowledge and their proficiencies after completing the course.

As such, the learning modules combine classroom and e-learning with hands-on simulators and virtual activities. In particular, in this project, we aimed to develop a first-of-its kind hands-on demonstrator to extend recently developed pure simulation-based approaches such as Alfalfa (NREL 2024).

Curriculum Modules

To address the gaps identified above, our curriculum includes three modules, which each include two lessons and corresponding learning objectives.

Module 1 – GEBs: Understand the impact of day-to-day operational decisions that operating a GEB has on operational costs, the grid, and the environment.

Lesson 1: Energy versus power

- Differentiate between units and measures of power versus energy.
- Explain how regular building operations and maintenance decisions affect a *building's energy and power consumption and generation.*

Lesson 2: Buildings and the electric grid

- Identify the different major components of the electric grid, how they present themselves on an electric bill, and learn about strategies used to reduce a building's electric load.
- Explain how regular building operation decisions affect the electric grid and building finances.

Module 2 – Occupant-centric building operation: Know the functionality of occupant centric controls, how they are used to automate building operations, and how energy efficient operations can be impacted by occupants' behavior.

Lesson 3: Building operation and people

- Understand the different aspects of the occupation "Building Operator."
- Identify properties of a building, the HVAC system, and the grid that can limit an operator's ability to provide occupant indoor environmental quality.

Lesson 4: Humans and buildings (see Figure 2 for example lesson agenda).

- Understand how occupant behaviors can impact the built environment and building energy performance: from occupant, to building, to grid scales.

Activity	Time	Topic
Discussion	15-min.	Our personal comfort
Lecture	15-min.	Thermal, visual, + acoustic comfort
Case Study	20-min.	Occupants taking control: how and why
Discussion	15-min.	Human behaviors and buildings
Break	10-min.	Break
Lecture	20-min.	Behavior and building energy impacts
Walkthrough	10-min.	Research Large units on roof
Summary	15-min.	Summary and review
	2-hour	

Figure 2. Example of Lesson (4) Agenda

Module 3 – Occupant-centric grid-interactive building operation: Be able to build a common understanding and a culture of collaboration between building operators and occupants to maximize building's energy efficiency and flexibility.

Lesson 5: Relationships between building operators and occupants

- Explain how a good relationship between building operators and occupants can help make buildings more efficient and effective GEBs.

Lesson 6: Effective building operation

- Understand potential strategies for using tenant engagement, communication, and education efforts to enhance occupant behaviors, comfort, and building energy use.

In the next section, we further explain how we leveraged interactive elements, activities, and hands-on learning activities to enhance overall learning and engagement in the curriculum.

Interactive Elements + Hands-on Learning

Whole-building operation demonstrator (BOEm). In this project, a hands-on whole-building operations demonstrator was developed to simulate student's first days "on the job" supervised by an excellent mentor who provides clear tasks in controlled environments to provide opportunities for learning. The demonstrator provides learning opportunities without risk to building owners and without the need of such a skilled mentor which are difficult to come by in an aging workforce with rapidly changing technologies. For example, the demonstrator provides a real BAS interface where the trainee can modify schedules and setpoints to meet the needs of occupants in a case study, and explore how pre-cooling, conservation setpoints, and occupant overrides may play a role in achieve energy management objectives like efficiency and peak reduction.

The feasibility of this demonstrator was built on recent work funded by DOE, including the project lead investigator's own work on hardware in the loop building simulations ((Sparn et al. 2018). In this prior work, a component in an Energy Plus model is replaced with a physical component such as a heat pump. Instead of testing the real heat pump interacting with a simulated building, the building operations emulator (BOEm) tests a real BAS with a simulated building, and optionally real building system automation components like thermostats and fan controllers. The proof-of-concept BOEm is shown in Figure 3, with the building simulation running on the left monitor, communicating over BACnet/IP with the BAS software running on the laptop and a physical BAS demonstrator on the right. The students can manipulate the BAS' interface, and the BAS control signals will be fed into the simulation. The simulation can run on the embedded computer in the demonstrator, or on a separate computer connected via ethernet (Kang, Velazquez, and Kane 2024).

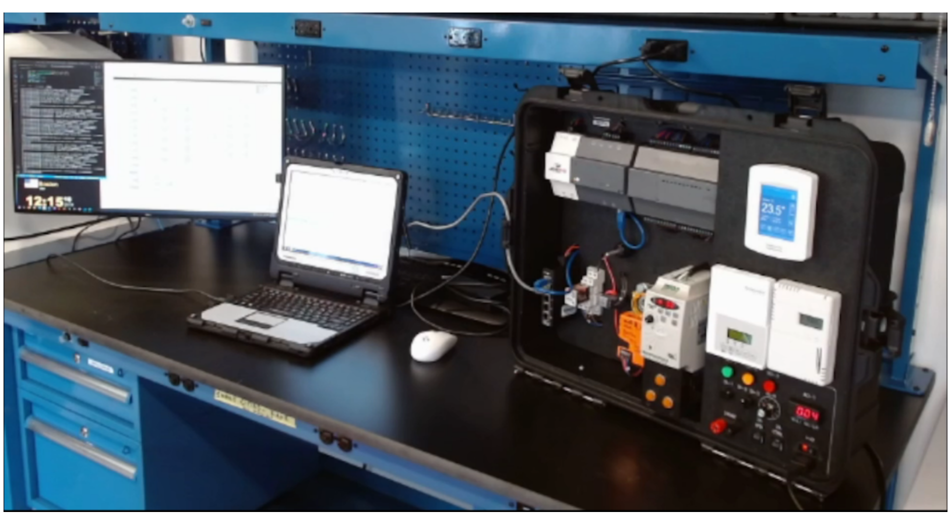

Figure 3. The BOEm proof of concept connected to an iConnect PT-181 BAS portable training unit providing a hands-on component.

Interactive Virtual Walkthrough. In addition to the BAS Simulator, our team also worked with a video production company and other partners to create a video-game-like interactive and virtual environment where students can walk through a digital twin of a real building while learning about different GEB, OCC, and occupant behavior facts along the way (*see Figure 4 for screen shots of what students see when navigating the model).*

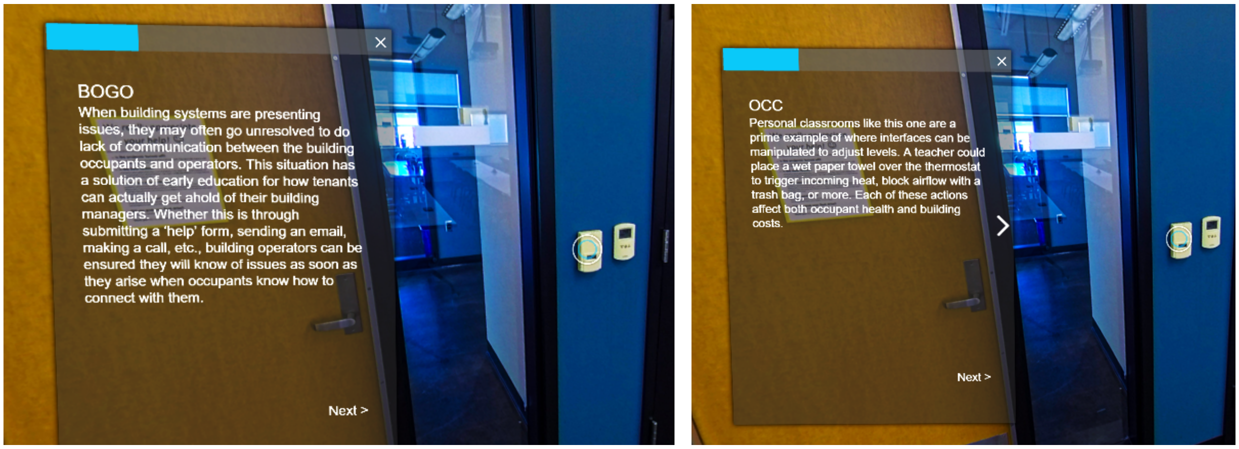

Figure 4. Example images of occupant/communication-based call outs in virtual walkthrough.

Of the prompts that is included in the walkthrough activity, students are prompted to consider how they as operators (and how the building occupants) can interact with and influence building controls, interfaces and energy profile/use. This approach allows future operators to understand how and why occupants might interact with the building and where problems, requiring clear communication, may be needed.

Case Studies, Discussion, and Activities. While this curriculum certainly heavily relies on lectures, it also incorporates these hands-on activities, discussions, walkthroughs, and videos to increase the overall learning impact. Many of these hands-on activities and discussions help students understand potential reasons and skill for dialogue between occupants and the Building Operator. One of the discussions and activities shows the students how occupants might "mess up" the building controls. For instance, there are images of occupant sensors that have been taped over, popsicles on thermostats, and more. Sharing these kinds of case study-based examples to students allow them to see how and why occupants might interact with the building to control their comfort (while also impacting energy outcomes). In the next lesson, students learn how they can best communicate with the occupants to minimize these types of behaviors.

In one lesson, students complete a communication style exercise, similar to a Myers-Brigg style test. This helps the students better understand their own communication styles and how they might differ from those they work with (or occupants). This helps students develop these types of important professional soft skills that are generally lacking in other building operator trainings. These types of activities encourage students to effectively communicate challenges with their colleagues and building occupants. Similar activities are included throughout the latter portion of the curriculum (modules 2 and 3) to tie together technical and soft skills. In another activity, students are taught about gathering comfort data from occupants through post occupancy evaluation (POE) surveys and interviews. They evaluate their personal thermal comfort in the space through conversations, discussions, and case study review.

Lessons Learned

Traditionally, BOC is taught to adult learners who already work in a facility and have access to building systems. This context and experience enables them to transfer theoretically acquired knowledge and apply it while working in their buildings. Since the BOGO curriculum targets a student body who has not yet entered the workforce, the curriculum was enriched with case studies, virtual walkthroughs, and a Building Operation Emulator - simulating a BAS - to create hands-on experiences for the students.

There are several lessons we learned through piloting this curriculum that we find useful to share for those who might be working on similar projects or workforce development:

- **Assessments**: The pre- and post-Assessments needed much more time than anticipated (i.e., in an attempt to gather data for program evaluation, we ate into valuable lesson time), because students needed a lot more explanations and guidance on how to complete an electronic survey. The levels of computer literacy differed greatly between the students, and it was challenging to provide the necessary individual assistance some students needed in the virtual zoom classroom
- **Timing**: The timing of the lectures was good overall, but we found interactive activities required additional time for engagement or discussion.
- **Slides**: Some slides needed minor editing for consistency's sake. For example, the font size of some slides needed to be increased, some graphics need to be aligned better. Ultimately, we hired someone to review the slides and handbooks to ensure overall formatting and graphic consistency. Even with careful editing along the way, this is one of the challenges with working across multiple teams, platforms, and institutions.
- **Instructor guide**: As we were teaching and following our own instructions, we found that the instructions for the activities needed to be more detailed for the instructors and students. For the emulator, goals and guidance for student engagement needed to be defined more precisely. The virtual walkthrough instructions also took more time than planned and needed more guided questions to go with it.
- **Handbook**: Students mentioned that a printed handbook in addition to the electronic slide deck would be helpful.
- **IAB**: We collaborated with an Industry Advisory Board (IAB), a mixed group of six subject matter experts chosen from various fields because it was important to the project team to have broad coverage of feedback. The members work in the Building Automation System/technical field, the design and operations side and educational institutions. During the curriculum development process, it is important to engage with teachers and industry experts alike. Leaving space for an iterative process, giving clear directions and setting expectations is crucial to receiving the feedback and different perspectives each individual has to offer.
- **Classroom management**: During the small-scale pilot, which was taught in person at Madison Park VoTech High School, the students read out of the handbook in a round-robin style and was followed by discussions. This works for the teacher and students there but may not always be transferrable depending on who the students are, the teaching style of the instructor, and the modality: in-person or online.
- **Curriculum iteration**: The feedback gained in the first and second phase highlighted the importance of the iterative curriculum development process to fully engage the target students and instructors. We were deliberate in choosing partners interested in industry

recognized credentials and flexibility in their existing curriculum. However, these partners did not sign up overnight, the years before the project kick-off the authors were engaging with Madison Park waiting for an opportunity like this BOGO project. We are grateful for the patience and dedication to the students and instructors at Madison Park, and the online students in the phase 1 feasibility study.

Discussion and Impact

The BOGO training program aims to improve communication between building operators and occupants to help manage buildings' energy demand to balance renewable energy on the electric grid. Throughout the training modules, we emphasize the importance of dialogue feedback, and expectation setting to reinforce the technical concepts of energy management. To better prepare the students who will soon join the workforce, our approach utilizes case studies, walkthroughs, and a building operations emulator that simulates real-word scenarios.

At the completion of the three-year DOE funded BOGO curriculum development project, we will have reached 75 students. Our next step is to scale the program to 200+ students per year within 3 years by creating a value-add credential to the BOC FEEBO curriculum as it spreads to VoTech schools, community colleges, and online programs nationwide.

Immediate Impact

- **Enhanced Skill Sets**: Participants in the BOGO training program have shown significant improvements in their understanding of GEB and OCC concepts. The hands-on training and real-world simulations have equipped them with practical skills that are directly applicable to their future roles as building operators.
- **Improved Occupant Relations**: The emphasis on communication and relationship-building has prepared trainees to manage occupant interactions more effectively, leading to better occupant satisfaction and reduced conflict over building controls.
- **Industry Recognition**: The BOGO training has been integrated into the Building Operator Certification® (BOC) program, providing graduates with a recognized credential that enhances their employability and career prospects.

Long-Term Impact:

- **Workforce Development**: By targeting community colleges and technical schools, the BOGO training program helps to fill a critical workforce gap in the building operations industry. These institutions serve as vital entry points for students pursuing technical careers, and the BOGO curriculum provides them with a strong foundation in modern building management practices.
- **Scalability and Adaptability**: The BOGO curriculum's adaptability allows it to be integrated into various educational programs beyond HVAC and facility management, including other technical fields. This broad applicability ensures that the program can meet diverse workforce development needs across multiple sectors.
- **Sustainable Building Operations**: As more building operators are trained in GEB and OCC practices, the overall efficiency and sustainability of building operations are expected to improve. This will contribute to broader energy conservation goals and support the transition to more resilient and adaptive energy systems.

Broader Impact

- **Community and Industry Engagement**: Feedback from our Industry Advisory Board (IAB) and participating educational institutions has been overwhelmingly positive. Stakeholders recognize the value of the BOGO training in addressing current industry challenges and preparing the next generation of building operators.
- **Policy and Educational Integration**: The success of the BOGO training program highlights the potential for integrating similar curricula into other educational and policy initiatives. By demonstrating the effectiveness of hands-on, interactive training, the program sets a precedent for future workforce development efforts in the energy and building sectors.

Conclusion

The BOGO training program represents a significant advancement in building operator education. By focusing on both technical skills and human interactions, the program prepares trainees to navigate the complexities of modern building operations. As we continue to refine and expand the curriculum, we anticipate that the BOGO training will play a pivotal role in shaping the future of the building operations industry, ensuring that it remains adaptive, efficient, and responsive to the needs of both buildings and their occupants.

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