

# **Developing Future Sustainability-Minded Technical Professionals - A Pilot Course Partnership with USGBC**

**Heather A. Kirkvold, PhD, PE, Jaime Van Mourik, AIA, LEED AP DB+C,  
Darci Oberly, AIA, LEED AP BD+C**

*James Madison University/U.S. Green Building Council (USGBC)/Green Business Certification Inc.(GBCI)*

## **Abstract**

This paper describes an undergraduate engineering technical elective developed for the James Madison University (JMU) Department of Engineering in partnership with the U.S. Green Building Council (USGBC). The course, ENGR 498 Green Building and Construction, was offered during the spring semester of 2017. During the course, students explored the topics of building science, construction, and the complexities of sustainable design through the lens of LEED certification programs. The goal was to support the development of sustainability-minded industry professionals and to introduce students to careers in green building and construction. Real-world experiences were achieved through engagement with existing on-campus LEED certified buildings, interacting with USGBC/GBCI professionals, and practicing architecture professionals. Site visits to an industrial construction site, a residential “green” construction site, and University buildings served as rich learning environments. Students learned how to perform energy audits, were given an introduction to energy modeling of structures, and performed an analysis of existing storm water collection systems for verification of targeted LEED point categories.

## **Keywords**

Green building, LEED, building science, construction methods, sustainable design

## **Introduction and Background**

The ABET accredited Engineering program at James Madison University has a mission to nurture engaged engineers as a community of conscientious and adaptable learners who develop solutions for the betterment of society. As an undergraduate-only program located within a large public PUI liberal arts university, the Madison Engineering (MadE) program is uniquely positioned to integrate the technical rigors of engineering fundamentals with the socio-cultural engagement provided by a strong liberal arts general education to develop the engineer versatilitist<sup>1,2</sup>. These goals are consistent with the described “Engineer of 2020” by the National Academy of Engineering<sup>3</sup>. In light of these goals and the fact that JMU Engineer class of 2020 has enrolled this year, there exists an urgency to implement integrated, multi-dimensional project-based learning. The development of such a program for the JMU engineering first year experience, as described by Gipson et al.<sup>4</sup>, encourages this complex problem-based learning. The design project curriculum centers on a two-year capstone design project, starting in the first semester of the junior year. Approximately half of the students in the course were simultaneously embarking on a required capstone design project related to sustainable building or site design.

This paper describes an undergraduate engineering technical elective developed for students interested in exploring infrastructure, building, construction, and sustainability in the built world. Student interest in the course topics, and in particular the USGBC partnership, was reflected by robust enrollment numbers and multiple override requests. Multiple teams of student capstone teams enrolled.

## **Objectives**

The goal of the partnership was to support the development of sustainability-minded industry professionals and to introduce students to possible careers in green building and construction. The course explored governing principles of construction of the built environment, building science, and the basics of green building with an emphasis on examining local LEED (Leadership in Energy and Environmental Design) certified buildings. Topics included building codes, building science, green building rating systems, LEED, energy audits, energy modeling, materials, construction, and certification systems. The learning outcomes included fundamental understanding of building science and principles of sustainable design and construction, and basic skills in energy audits and identification of improvement strategies for existing buildings. The course was organized into three interconnected parts: fundamentals of building science, sustainable design using the lens of LEED certification programs, and construction methods for buildings. To encourage students to engage with ideas, multiple modes of instruction were used. Aimed at active learning, these modes included short lecture-based instruction, guest speakers, problem based learning (PBL), and multiple case studies with site visits.

## **Why LEED? Why JMU?**

LEED, or Leadership in Energy and Environmental Design, is the most widely used green building rating system in the world. Immediately recognizable to students, USGBC and LEED provides motivation to the student, and a structure for the introduction and application of core topics in sustainability. USGBC is proactively developing teaching resources to support post-secondary education. This course piloted the use of Education @USGBC, a subscription-based online platform containing sustainability content and resources that were integrated into the course. Since the completion of the course, USGBC has released free higher education curricular toolkits in Fall 2017. The three currently available toolkits focus on the topics of Green Building Design and Construction, Green Building Operations and Maintenance, and Sustainable Sites.. USGBC offers a more immersive and experiential opportunity for higher education through LEED Lab, an immersion course partnership with the host university. LEED Lab utilizes the built environment to educate and prepare students for the green building industry. Students evaluate the performance of existing facilities on campus and facilitate the LEED for Building Operations and Maintenance (LEED O+M) process with the goal of certifying the facility. LEED Lab requires significant commitment from the university, instructors, and USGBC, and therefore this course not started at this time, but remains an option for future development at JMU.

This exploratory course partnership represents a co-beneficial partnership supporting the mission of the university and USGBC, and leverages the existing organizational membership, JMU's commitment to sustainability, and the existing facilities and resources on campus. The James Madison University vision is "To be the national model for the engaged university: engaged with

ideas and the world.” This vision represents the JMU drive to partner with industry, government, and organizations to facilitate change. Starting as an organizational member with USGBC in 2006, JMU has actively committed to construct significant structures on campus in accordance with LEED certification (at some level), and retains professionals with LEED AP certifications on staff. Since 2010, a total of 13 projects, ranging from new construction to renovations, have been certified or are currently registered at all levels of LEED certification, including Platinum, Gold, and Silver Certifications. Perhaps most importantly, faculty were available to respond to a request from USGBC to partner in developing this pilot course.

### **Experiential Application of Concepts**

During the course, students explored the topics of building science and construction, and the complexities of sustainable design through the lens of LEED certification programs. Real-world experiences were achieved through engagement with existing on-campus LEED certified buildings, and interacting with USGBC/GBCI professionals and practicing architecture professionals, as shown in Fig. 1.



Figure 1. Charles Hendricks, architect with The Gains Group Architects, teaching students about reading drawings and wall cross sections.

Site visits to an industrial construction site, such as Fig. 2, a residential “green” construction site, and existing University buildings, served as rich learning environments. Students learned how to perform energy audits, were given an introduction to energy modeling of structures, and conducted an analysis of existing storm water collection systems for verification of targeted LEED point categories.



Figure 2. Construction site visit at the JMU Convention Center and hotel.

Students were taught how to perform energy audits using thermal infrared (IR) imaging by guest speaker, Mr. Charles Hendricks, Architect, of The Gaines Group Architects. Teams of 4 students were provided thermal IR imaging cameras and assigned to perform an energy audit for specified areas of the Engineering and Geosciences Building at JMU. Students completed energy audits for the entire building, however the reports were deemed not complete enough to compile into a comprehensive report for the building.

### **The Lehman House**

Mr. Hendricks arranged for the class to tour the construction site for a “green” house in Harrisonburg, VA. The house owner, a business professor, was working to design and build the “greenest house possible” using affordable readily available technologies. He explained the strategies for the project to become net carbon neutral over its life-span, Fig. 3. A highlight was the inclusion of passive design through site positioning and a trombe wall to harness solar radiation and regulate inside temperatures during the winter months. Students were also particularly intrigued with the insulated concrete unit (ICU) construction.



Figure 3. Construction site visit at the Lehman House to study sustainable construction and design.

### **Other Case Studies and Site Visits**

Additional assignments and site visits to on-campus buildings included the construction of a parking garage, hotel, and conference center, the Biosciences building, and the student recreation facility. The conference center construction provided opportunities to see construction methods discussed in class. The Biosciences building was the focus of an assignment to verify the sizing of a water retention pond. Students obtained historical local weather data and determined the appropriate rainstorm for sizing the pond. They calculated the required pond capacity and then evaluated the constructed pond for compliance with the determined sizing needs. Finally, the final exam was developed with the purpose of allowing students to exercise their new knowledge of sustainability, construction, and LEED certification by performing an initial comprehensive evaluation of the University Student Recreation Facility. Students were able to determine existing sustainability features (and weaknesses) of UREC, Fig. 4, and some were able to provide conceptual design changes to upgrade the sustainability of the facility.



Figure 4. Light emission from the University Recreation Center, a Silver-Level LEED certified building at James Madison University in Harrisonburg, VA.

### **Addressing Challenges**

Though the students exhibited enthusiastic interest in topics, the student's lack of (curricular) exposure to structural (infrastructure) design and construction was immediately evident. Due to a wide-range of study levels (sophomores through seniors) many of the students had only a cursory exposure to reading building plans. To address this challenge, the next iteration of the course will likely begin with construction and introduction to building, to create a foundation of understanding (and vocabulary) from which building science topics can then be logically addressed. Additionally, a prerequisite course of sophomore design will likely be required to ensure students have skills in engineering drawing.

The proposed schedule was too ambitious. Understanding the LEED system required more time than anticipated. Coordination between JMU and USGBC/GBCI, as well as with professionals was challenging given the scheduled class time and instructor teaching load. Also, specific assignments will be revised. The energy audit project will be limited to spaces, such as classrooms, with doors to remove the complexity of performing an energy audit on the open high-ceiling lobby and connecting hallways. Example design calculations for sizing a bioretention pond will be provided prior to the Biosciences building assignment.

### **Summary and Future Work**

The ABET accredited engineering program at JMU partnered with USGBC to develop a technical elective course. The goal of the partnership was to support students in their development towards becoming sustainability minded technical professionals. Learning

objectives were ambitious; students were exposed to a wide breath of building and sustainability applications. Course reviews indicated the students believed the site visits were the highlights and they desired greater technical depth in exchange for the breadth of content. Future versions of the course will include more project based learning (PBL) with data analysis emphasis. To achieve this, the scope of the course will need to be reduced and refocused. An example semester project is the collection and analysis of energy consumption data for on-campus LEED-certified buildings, to compare actual performance with intended design performance. The LEED Lab program is considered a viable option for providing a greater depth of content.

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## **Heather A. Kirkvold, Ph.D., P.E.**

Dr. Kirkvold is a licensed professional engineer with all degrees in Civil and Structural Engineering. She has more than 14 years of industry experience and is currently in her 4th year of teaching as an assistant professor of engineering at James Madison University. Dr. Kirkvold is a member of ACI International, TRB materials committees, and ASCE. She teaches engineering materials, mechanics, project management, introduction to engineering decision-making, engineering design, as well as sustainable building and construction. Her research technical focus is improving durability of infrastructure, with specific areas such as concrete mixture design, cracking of concrete, freeze-thaw deterioration, aggregates, construction methods, Low-Cracking High-Performance Concrete (LC-HPC), and bridge deck durability.

## **Jaime Van Mourik, AIA, LEED AP DB+C**

Ms. Van Mourik is the Vice President for Education at the US Green Building Council. She has spent her career educating people of all ages on sustainability and green building concepts, and works to help them integrate sustainable practices into learning spaces. Jaime believes education is the catalyst for change, and is committed to building innovative, sustainable and healthy spaces where future generations can learn and prepare for a changing world. She leads USGBC’s education work, including overseeing the Education @USGBC platform, a best-in-class green building education tool for professionals and post-secondary audiences, and Learning Lab, a leading-edge resource for K-12 sustainability curricular materials. She also spearheads USGBC’s higher education initiatives, which includes transforming physical campus spaces while also improving the academic environment so that all students are equipped to lead. She is a LEED AP

and an Associate AIA member with a bachelor's degree in architecture and a master's degree in architectural history.

**Darci Oberly, AIA, LEED AP BD+C**

Ms. Oberly is a Senior Certification Reviewer with Green Business Certification, Inc. An architect by training with prior experience designing buildings pursuing LEED certification, Darci has been performing LEED certification reviews since 2008. Her LEED expertise is with energy/HVAC submittals, which is also utilized to educate project teams on LEED requirements, to train new reviewers, and to develop LEED AP exam content. She holds an architect license in New York and in Illinois, and is an AIA member and LEED AP.