SOLAR DECATHLON DESIGN CHALLENGE: A COLLABORATIVE STUDENT-COMMUNITY ENGAGEMENT PROJECT

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Abstract: To prepare our students for their chosen careers, it is important to provide opportunities that integrate their past studies and apply these through civic engagement. The Solar Decathlon competition sponsored by the U.S. Department of Energy (DOE) can be such a platform that challenges student teams to become involved with their community and apply their knowledge and design highly efficient and innovative buildings. According to the DOE, the Solar Decathlon competition provides participating students with unique training that prepares them for the clean energy workforce; educates students and the public about the latest technologies and materials in energy-efficient design, smart building solutions, and demonstrates to the public the comfort and savings of buildings that combine energy-efficient construction and innovative designs including onsite renewable energy production. Considering the dual benefits of this program, the Engineering Technology final year students at Fitchburg State University have participated in the Solar Decathlon Design Challenge. Under the supervision of faculty, students in coordination with local authorities selected a downtown urban property for redevelopment following the guidelines of the Solar Decathlon project competition. This paper presents the importance and challenges of this type of collaborative community engaged project to enhance the learning opportunities for undergraduate students. Moreover, it highlights the benefits of this type of real-world project in capstone course curricula.

Key Words: *Civic engagement, Solar Decathlon, classroom learning, education.*

1. INTRODUCTION

There is a frequently asked question, "does the traditional university classroom learning and education process of lecturing professors, passive note takers and anxious examinees develop the skill set that graduating professionals need?" (Holt et al., 2012). Most academicians and professionals agree that the traditional academic environment does not provide practical skills and exposure to the real-world problems that are meaningful and engaging to the students to become effective professionals upon graduation (Bernold, 2005; Holt et al., 2012). They must "balance technical solutions with social, cultural, environmental, economic, and sustainability concerns, in an environment that features multidisciplinary peer interaction and mentoring" (Fiori & Songer, 2009). Participating in the Department of Energy (DOE) Solar Decathlon program is a real-world learning environment that cannot be replicated in the classroom (Grose, 2009). The students and faculty involved were challenged beyond what they would have experienced in the classroom setting and what they learned could not be replicated in the traditional university learning environment (Holt et al., 2012). The ultimate beneficiaries from the outcomes of this type of program are university entity (especially students and faculty), industry, and community. Therefore, it is worth taking bringing all entities on board as partners during the execution of the project.

The partnerships among universities, communities, and organizations connect faculty and students

with communities and organizations and also provide a common platform for concerned stakeholders to share knowledge, learn by serving communities, integrate community serve-learning models into the academic curriculum, and provide an innovative pedagogical approach to realizing higher education's civic responsibilities (Driscoll et al., 1996). These partnerships ultimately improve the quality and productivity of instruction as well as address community problems (Bringle, Games, & Malloy, 1999; Bringle, Hatcher, & Games, 1997; Driscoll et al., 1996; Edgerton, 1995, Nicotera et al., 2011).

This paper explains a framework to conduct a Faculty-Students-Community Engaged (FSCE) project. A FSCE project provides a common platform for all stakeholders (such as faculty, students, community representatives, local industry, professional organizations, and city officials) to identify existing issues in a community or city (Mani & Chenot, 2020). FSCE projects also create dual opportunities for students in both learning and community service. This research not only contributes to the body of knowledge but also develops a foundation for designing a systematic strategy for the effective implementation of a FSCE project. In addition, this paper presents a case study that shows the feasibility of the proposed framework and also shows how Fitchburg State faculty and students contributed to the welfare of the city. Moreover, this paper explores and presents how to integrate learning outcomes from the Solar Decathlon project into a program's curriculum.

2. BACKGROUND OF PROJECT SITE

Fitchburg, with a current population of about 41,000, was first incorporated in 1764. Because of its location along the Nashua River and access to early water power, it grew as part of this country's early industrial revolution and even more rapidly after the 1830s when the railroad connected it with the rest of the country. As manufacturing expanded, Fitchburg grew and integrated many waves of immigrant workers and their families.

During the mid-to-latter part of the 20th Century, the city's industrial base gradually moved away and suburbanization and shopping malls progressively devalued the city's once vibrant urban Main Street. The most recent structure located at 510 Main Street was the Johnsonia Hotel block built in 1898. It was a mixed-use building with retail and offices on the first two levels, hotel rooms on floors 3rd and 4th and an elegant restaurant dining room at the top level. More recently, the building was converted to condominiums maintaining its business/residential mix, but it was unfortunately destroyed by fire in 2011.

Today, the City of Fitchburg is working to revitalize its once vibrant downtown. At the same time, the Commonwealth of Massachusetts is facing a housing crisis, and, in particular, affordable housing. Recently, Fitchburg was again connected by commuter rail to the east and North Station in Boston. To help alleviate the housing shortage and create livable, walkable, energy-conscience communities, the state has designated Fitchburg along with other cities on the commuter rail network as Gateway Cities. This designation provides additional planning assistance, grants and funding avenues for Gateway Cities to succeed adding planning tools to achieve thriving, mixed-use, walkable cities. These include the City's downtown zoning Smart Growth mixed-use overlay district, the Massachusetts Transformative Transit-Oriented Development (TTOD) initiative, and the Transformative Development Initiative (TDI) with grants and planning assistance. These initiatives and planning tools are in place and drive the development of 510 Main Street.

2.1 Solar Decathlon

The Solar Decathlon Design Challenge is annual competition organized by U.S. Department of Energy (DOE), first began in 2014. In this competition, the selected teams design the energy-efficient, architecturally appealing, engineering excellence with innovation, and affordable solar-powered homes as per given guidelines (DOE, 2020). U.S. Department of Energy (DOE) states that "the Solar Decathlon Design Challenge continues to build a global community of current and future professionals dedicated to providing solutions to complex problems related to climate change, affordability, and environmental justice through building design." This competition provided an opportunity to demonstrate and educate participants that these types of solar-powered homes can be affordable as well as energy-efficient.

Fitchburg State University (FSU) was selected as one of the finalist teams from around the globe to participate in the Solar Decathlon Design Challenge 2021, held remotely because of Covid-19 pandemic. The building described in this paper was designed by the students of FSU for this competition with the help of faculty from the Engineering Technology Department.

Teams entering the Design Challenge must select from seven allowable building types (divisions) to create their design (DOE, 2020), such as (i) Suburban Single-Family Housing, (ii) Urban Single-Family Housing, (iii) Attached Housing, (iv) Retail Building, (v) Office Building, (vi) Elementary School, and (vii) Mixed-Use Multifamily Building. Buildings in this completion were judged based on 10 factors (contests) which are: Architecture, Engineering, Market Analysis, Durability and Resilience, Embodied Environmental Impact, Integrated Performance, Occupant Experience, Comfort and Environmental Quality, Energy Performance, and Presentation (DOE, 2020).

The value of competitions, such as the Solar Decathlon is that they engage students in authentic and complex learning activities relevant to their degrees (Cooper et al., 2014). Barth et al. (2007) indicated how difficult it is to develop key competencies for sustainable development as this requires the opportunity for both formal and informal learning in an interdisciplinary environment where students can develop self-responsibility. Kos and de Souza (2014) outlined how the Solar Decathlon competition has provided an invaluable vehicle to engage the public, industry, and academia in promoting excellence in renewable energy and sustainable buildings teaching and research. By linking research activities in solar power, sustainable housing, energy modeling etc. with learning activities and practical outcomes, the Solar Decathlon provides a great opportunity to create a multi-disciplinary research-teaching nexus (Cooper et al., 2014).

3. RESEARCH FRAMEWORK

Authors have developed a research framework to conduct Faculty-Students-Community Engaged (FSCE) projects as shown in Figure 1 (Mani and Chenot, 2020). This is a generalized framework which can be updated based upon project requirements.

Through the case study on the Solar Decathlon project, this paper explains how the FSCE framework is compatible for students-community engaged project and how multiple stakeholders are interlinked for the sustainable development of the city. The concerned stakeholders for this specific project are faculty, students, community representatives, utility company representatives, and Solar Decathlon Design Challenge project review team. Through extensive discussion, investigation and design, effective plans and strategies are then prepared for implementation toward sustainable redevelopment in the city. The collected information, detailed plans, strategies, and outcomes from the project are recorded and shared among all concerned parties for review and adaptation.

For this Solar Decathlon Design Challenge, the students reimagined the site of the former Johnsonia Building, a hotel-turned-apartment complex that was demolished after a fire in 2011. The team collected project specific information from various sources, such as City officials and community representatives. In designing a new structure for the location, the students considered a mixed-use, multifamily development that would serve Fitchburg's ethnically diverse population with retail and commercial space that also provided affordable housing. The design accomplished this while adhering to the net zero energy footprint (wherein energy used by the building is offset by what is produced on-site) through maximizing daylight, capturing solar energy, and geothermal heating and cooling systems.

Upon completion or during the working process, achieved learning outcomes are further integrated and adopted into the relevant course curriculum for future students. The learning outcomes from this project are incorporated for the Engineering Technology Capstone curriculum.

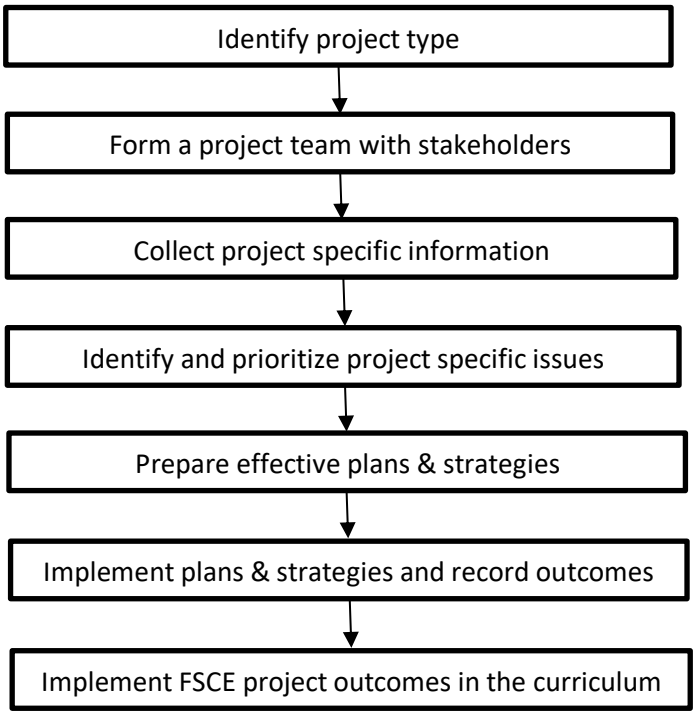

Figure 1 Research framework (Adapted from Mani and Chenot, 2020)

4. CASE STUDY

After discussion with concerned parties, the Johnsonia Hotel building block (located at 510 main street, Fitchburg, MA) was selected for the case study. Built in 1898, this building was a mixed-use with retail and offices on the first two levels, hotel rooms on floors 3 and 4 and an elegant restaurant dining room at the top level as shown in Figure 2. But it was destroyed by fire in 2011. The land coverage is just over 15,000 sf and is adjacent to an underutilized five-level municipal parking garage.

The site is located within one block from a second public parking structure and is within easy walking distance to the commuter rail/intermodal center, the Fitchburg Public Library, City Hall, a post office branch, a soon-to-be revived live theater building, several churches, a mosque, and Monument Park and Riverfront Park. Also close by, are the Fitchburg Art Museum, the Longsjo Middle School, and Fitchburg State University. The property has great potential to contribute positively to the City's Smart Growth development and again becoming a rich urban experience for all. This planning has paid off as downtown Fitchburg is beginning to re-find its urban advantage. Two new restaurants and a brewery have recently opened, and older mill and school buildings are being transformed for new uses.

The target market is for equitable business and housing opportunities for today's Fitchburg citizens and new arrivals who thrive on urban convenience and community. Fitchburg, as with most communities, is represented by a new mix of ethnicities and age groups. This project will add density and diversity of people and activities to this community rich with heritage.

Under the guidance of Prof. D. Keith Chenot and Dr. Nirajan Mani, nine Engineering Technology Capstone and four Construction Management Capstone students were involved in this project. Construction Management Capstone students were responsible for estimating and life cycle assessment and Engineering Technology Capstone students were responsible for architecture design, market analysis,

energy, and others. Industry experts from Unitil Electric Company were also invited for presentations and sharing their working experiences in various aspects of the project.

Figure 2 Johnsonia Hotel Block

5. RESULTS & DISCUSSION

The project addresses the following goals of the Solar Decathlon project requirements.

5.1 Architecture

This project adds to the convenience and quality of urban living. Retail and commercial services at street level are highly visible on this prominent downtown corner. Upper level apartments are configured to maximize views and daylighting. Units are designed to be affordable and designed for modern households, such as space for work-at-home. Internal corridors and stairways will have daylighting and quality materials to celebrate socialization, physical activity, and reduce reliance on the elevator. Rooftop and terrace gardens will provide areas for outdoor living. A mid-level connector to the adjacent municipal parking structure will provide easy and secure access to reserved tenant parking, including additional EV charging for the structure.

5.2 Engineering

The structural systems will utilize low carbon reinforced concrete at the base and carbon-sequestering mass timber and other framing systems above. The building envelope will be designed to highly regulate thermal transmission, manage moisture migration, be durable, and integrate with the building design. Heating and cooling will be first through natural ventilation with operable glazing and then with advanced heat pump technology evaluating both geothermal and air systems. Mechanical ventilation will be through heat and moisture transfer systems linked to CO_2 and occupancy monitoring. Plumbing will feature low-flow fixtures and hot water systems using heat recovery and heat pump technology. Roof and terrace rain water collection will be stored and distributed for water closet flushing and rooftop garden irrigation.

5.3 Market Analysis

Demand for affordable and equitable housing and small business development in Massachusetts is high, particularly in commuter rail hubs like Fitchburg. To meet this demand, State and City funded incentive programs have been developed geared toward livable cities, affordable housing, and local commerce. This type of development is encouraged by the City's recent Smart Growth zoning mixed-use overlay district, and through other state incentive programs.

5.4 Durability and Resilience

Fitchburg's varying climate conditions mandate an integrated design approach to selecting materials and designing systems that function both passively and are resiliently.

5.5 Embodied Environmental Impact

The project is focused on abating its life cycle environmental impact by selecting materials that minimize extraction, that favor renewable or low embedded energy and that, where possible, are locally sourced. The project's location utilized the city's existing urban infrastructure, and encourages walkable low energy connections to shopping, services, and mass transportation all reducing the project's environmental impact.

5.6 Integrated Performance

The project's location and proposed uses are integrated to enhance the diversity and benefits of urban living. The building's integrated design approach creates a highly functional result that minimizes energy use through passive design and sound engineering principles to maintain comfort while minimizing energy consumption and environmental degradation.

5.7 Occupant Experience

The project's downtown location allows easy walking access for all. Ground level retail/commercial spaces have high visibility, daylighting, rear service access, and efficient, low energy HVAC systems. Upper level apartments will be designed to maximize daylighting and natural ventilation. The units will have functional layouts reflecting today's modern living, efficient low energy, low cost environmental systems, appliances, and lighting. Rooftop and Level 2 courtyard spaces are dedicated for outdoor living and garden plots for tenants.

5.8 Comfort and Environmental Quality

Daylighting, sound control between units, monitored ERV air quality, efficient heat pump technology, and shared terrace and rooftop green space add to occupants' comfort.

5.9 Energy Performance

Performance to achieve EUI goals will be evaluated using energy modeling software. Energy goals will also be compared with Massachusetts's newly proposed Mass Zero-Energy Code, one of the nation's most energy conscience regulations. Clean PV energy generation is minimized with the reduced footprint of the proposed design's upper levels, but this project will (i) in partnership with the city, investigate adding a large PV array over the adjacent 5-level municipal parking garage and share the produced energy with each building and provide EV charging stations, and (ii) purchase off-site renewable to replace nonrenewable energy sources.

5.10 Presentation

Students presented their complete project work to the judge panel and audience virtually because of Covid-19 pandemic. They explained their proposed design drawings (preliminary proposed drawing as shown in Figure 3), estimated costs, and timeline to complete the project in their report. Their performance was evaluated by the judge panel and awarded certificate of participation to them.

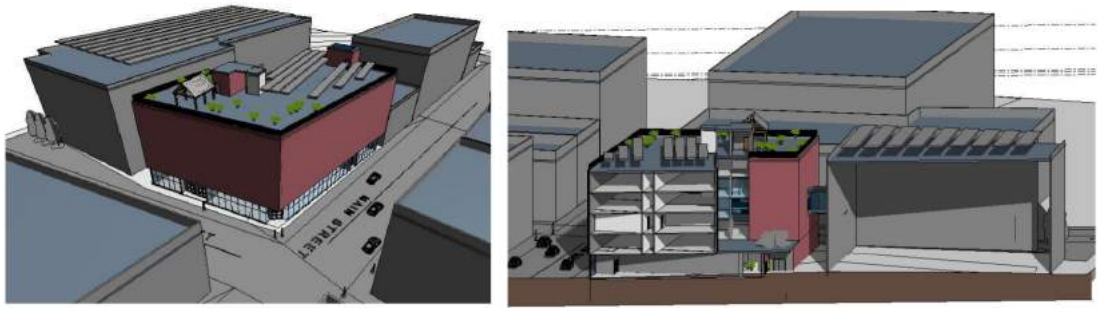

Figure 3 Proposed Design of the Johnsonia Hotel Project

6. CONCLUSIONS

This paper shows how the project team introduced the Solar Decathlon Design Challenge Competition and linked as a faculty-students-community engaged project and integrated its learning outcomes into the program curriculum. The faculty-students-community engaged project helps to build a strong relationship between Fitchburg State University, Fitchburg city officials, residents and community, and concerned stakeholders. This project also helps the urban planner and concerned authorities to plan and execute effective strategies for the development of Fitchburg city. Because of this type of project, students will realize their responsibility towards their community. This type of project can be a foundation and common learning platform for students who want to do real project for their senior level projects, such as capstone courses.

7. ACKNOWLEDGEMENTS

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