



Integrating Micro-House Design and Construction into the Construction Management and Engineering Curriculum

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Integrating Micro-House Design and Construction into the Construction Management and Engineering Curriculum

This paper shows how micro-house design and construction projects are integrated into the curriculum in Norwich University’s Civil Engineering and Construction Management programs.

Norwich University’s Architecture, Engineering, and Construction Management programs’ first two full-scale house design and construction projects involved a solar powered lab and a solar powered house. During these two projects, the various Architecture, Engineering, and Construction Management programs began collaborating, integrating students from the various disciplines into a single project team. The Micro-House Related Design/Construction Projects, shown in Table 1, reflect Norwich University’s institutional support of experiential learning. Lessons learned from the design and construction of each project were used to refine the projects for subsequent years.

Table 1: Norwich University Micro-House Related Design/Construction Projects

Project	Size	Date
Embarc – Solar Powered Lab	160 sq.ft.	2009-2010
Rae(v) – Solar Decathlon Prototype	1100 sq.ft	2010-2011
Solar Decathlon	988 sq.ft	2011-2013
NHS Outdoor Classroom	576 sq.ft	2014-2015
CASA 802 Micro-House	336 sq.ft.	2015-2016
Wheel Pad Micro-House	204 sq.ft.	2016
Fontaine Mills Micro-House	288 sq.ft.	2016-2017
CASA 802.1 Micro-House Addition	240 sq.ft.	2017-2018
NEST Outdoor Classroom	224 sq.ft.	2017-2018
Race to Zero Multi-Family House	800 sq.ft/unit.	2017-2018

Project Descriptions

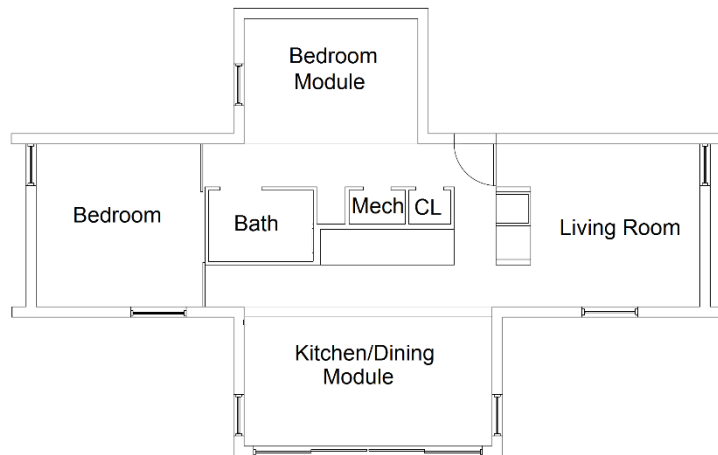
Embarc/DOG House – Solar Powered Lab¹

The first multi-discipline design build project was the design and construction of a solar powered portable laboratory, shown in Figure 1. Architecture students worked on the design of the project, with structural work being done within the Civil Engineering department. The project was constructed by team of architecture and construction management students. The project was named “Embarc” by the architects working on the project and the “DOG house” by the Department of Geology students who now use the laboratory.



Figure 1: Embarc/DOG House

The next project was the construction of a prototype house to prepare for the U.S. Department of Energy Solar Decathlon competition, in which collegiate teams design, build, and operate solar-powered houses that are intended to be cost-effective, energy-efficient, and attractive. The Solar Decathlon is intended to educate students and the public about the economic and environmental benefits of energy efficient, solar powered homes. As shown in Figure 2, the Rae(v) House¹ was



a prototype Solar Decathlon house, which consisted of a 14 ft wide by 49 ft long main section with room modules added to sides of building. This structure was designed by an integrated team of architects, civil engineers, and construction management students. Problems often occurred between the various students due to the discrepancies between when information was needed by one discipline to complete a task and when other disciplines were able to produce that information.

Figure 2: Rae(v) House Floor Plan

Following the Rae(v) house, the university submitted a successful entry to participate in the Solar Decathlon competition. A multi-disciplinary team was used to design the ΔT -90 house², named for the 90°F difference between inside and outside temperatures that residents of Vermont experience each winter. Once again, the design team members included architects, engineers, and construction managers. However, on this project the architects started working on floor plans and other items before the engineering and construction management students started full-time work on the project. During this initial design stage, the architects brought in engineers and construction managers to consult as necessary. After design concepts were substantially complete, the construction managers played a larger role in developing construction documentation, specifications, and plans for construction.



Shown in Figure 3, the ΔT -90 house officially placed first in the Affordability Contest of the 2013 Solar Decathlon Competition with an estimated cost of \$168,385 for a 994 square foot house (approximately \$170 per square foot), while scoring 100% for the energy balance portion of the competition.³ This house is the most economical house in the history of the competition.

Figure 3: ΔT -90 House at 2013 Solar Decathlon Competition

After the Solar Decathlon project, faculty worked on a series of smaller projects. For the Northfield High School outdoor classroom⁴, shown in Figure 4, Construction Management students designed and constructed foundations in the Fall semester based upon design information from the Architecture students. The Architecture students then designed and constructed the outdoor classroom in the spring semester. Due to design changes after the foundations were constructed, the architects called upon the civil engineers to provide structural design assistance.



Figure 4: Northfield High School Outdoor Classroom

Shown in Figure 5, the CASA 802 Micro-House⁵ project involved the design of a 12x28 which could serve as either a stand-alone house, or as the core of a house to which extra rooms could be added in the future.

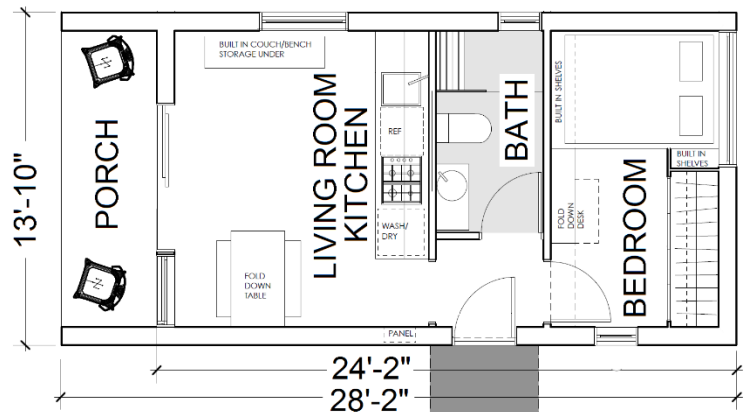


Figure 5: CASA 802 Micro-House, perspective view and floor plan

This house was designed by architecture students with consulting from structural, electrical, and mechanical engineers, and was constructed by a mix of construction management students from the “CE458 – Structural Issues for Construction” course, architecture students, and engineering students. Like several of the other structures listed, this house was constructed on campus and then transported to its final location.



The Wheel Pad⁶ Micro-House, shown in Figure 6, is an ADA compliant bedroom/bath addition for an existing house. This project was designed by LineSync Architects, and constructed by Construction management and engineering students. All construction scheduling, procurement, and management activities were done by construction management students.

Figure 6: Wheel Pad

As shown in Figure 7, the construction space used for these projects presented significant challenges. The construction of a new shared building, called the CoLaboratory, has greatly simplified construction.



Figure 7: Design Build Space, “mid-Spring” in Vermont

The CASA 802.1 Micro-House⁷, shown in Figure 8, was the first structure to be built in the CoLaboratory building. The CASA 802.1 Micro-House was designed to add an ADA compliant bedroom/bath to an existing house.



Figure 8: CASA 802.1 - ADA Accessible Bedroom/ Bath, construction progress in CoLab

This project was designed by a mixture of Norwich students and architects from LineSync Architects. The construction is being undertaken by construction management and engineering students.

Curriculum Integration

Norwich University's Architecture, Engineering, and Construction Management programs have taken the experience obtained from working on these projects and have integrated design and construction work into their respective curricula.

For example, the Construction Management curriculum has incorporated various aspects of the Micro-House Design/Construction projects into several courses distributed throughout the curriculum:

Freshman Year

Spring	Introduction to Construction Management
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Sophomore Year

Fall	Specifications and Estimating.
Spring	Building Information Modeling.

Junior Year

Fall	Construction Management.
Spring	Construction Productivity, Construction Safety.

Senior Year

Fall	Structural Aspects of Construction, Project Management.
Spring	Production/Operations Management.

All semesters: Students work on Micro-house projects.

Throughout the curriculum the Construction Management students use the micro-house as a basis for several assignments and projects. Starting in the freshman year, the students in Introduction to Civil Engineering/Construction Management utilize the micro-house projects for construction site visits, and as a subject for the introduction to Building Information Modeling (BIM). The students in the estimating classes determine the material quantities required for the micro-house. The students in the Construction Management, Construction Productivity, and Construction Safety classes, the students apply material from their coursework to create construction schedules, improve productivity, and monitor worksite safety.

For example, in EM210, Building Information Modeling and Integrated Practices, the Construction management students use the micro-house project as the basis for several assignments and projects. An example of the student work is shown in Figure 9, in which the students designed ADA compliant ramps to provide access for individuals in wheelchairs.

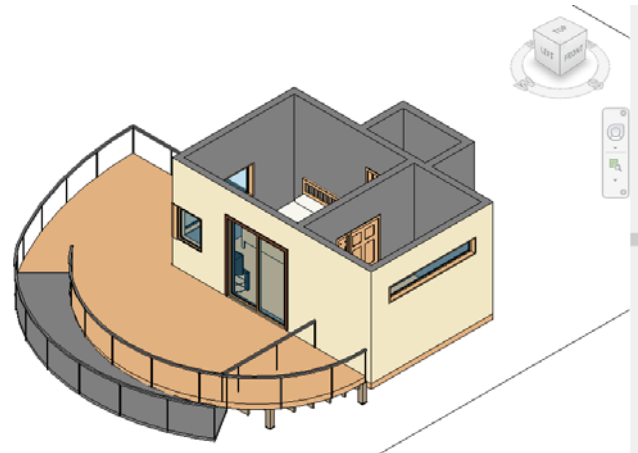


Figure 9: Micro-House BIM

Similarly, both the Civil Engineering and Architecture programs have incorporated aspects of the Micro-House Design/Construction projects into their curricula. As an example, the Civil Engineering structural analysis class used the truss from the outdoor classroom as one of their class assignments, their design work (Figure 10) was used by the constructed management students to fabricate the roof trusses (Figure 11).

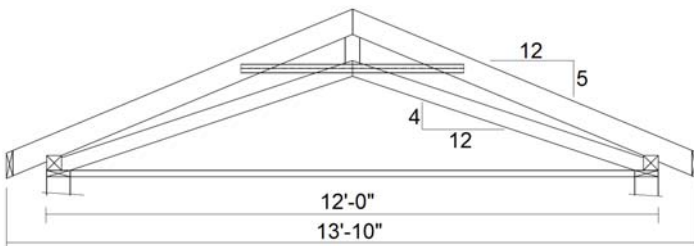


Figure 10: Roof Truss – As Designed



Figure 11: Roof Truss – As Constructed

This use of Micro-House Design/Construction projects in the curriculum exposes students to material that is realistic, but not of overwhelming scope⁸. The students are given assignments that are manageable, and that increase in scope and complexity over the course of a student's academic career. As a particular project progresses over time, students will be involved in the estimation, purchasing, planning, management, and finally the construction of a micro-house. Finally, the students get to have hands-on experience along with their academic coursework, which is key for improving both student learning and retention.

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