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Work-in-Progress: In the Doghouse with Construction Management and Electrical and Computer Engineering Technology Students: A Collaborative Course Project With A Community Service Opportunity

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Abstract
This work-in-progress paper presents an interdisciplinary, service-based learning project involving undergraduate students from Construction Management (CM) and Electrical and Computer Engineering Technology (ECET) programs. Six CM student teams designed and constructed insulated dog houses using engineered wall panels with integrated lighting and thermal management features. One doghouse was intended to function as a shelter and charging station for a mobile robotic platform, while the remaining structures were designated for donation to a local animal rescue organization.

To simulate professional practice, CM teams developed performance-based electrical requirements and presented them to ECET students enrolled in a Microcontroller Applications course, framing the interaction as a general contractor-electrical subcontractor relationship. ECET teams designed custom electronic systems incorporating sensors, lighting, and fan control logic and formally proposed their solutions to the CM teams. CM students evaluated the proposals and selected one electronics design for implementation.

The project resulted in multiple graded deliverables in both courses and the construction of physical artifacts with community impact. This paper describes pedagogical motivation, project structure, and early observations, with formal assessment planned for future reporting.

Keywords
Multidisciplinary, Engineering Technology, Construction Management, Faculty Paper

1. Introduction and Motivation

Engineering and construction education faces an increasing need to prepare graduates for professional environments characterized by interdisciplinary collaboration, evolving requirements, and system-level complexity [1], [2]. In the architecture, engineering, and construction (AEC) industry, graduates are expected to integrate technical knowledge across disciplines, communicate effectively with diverse stakeholders, and adapt to changing project constraints [1], [3]. However, many undergraduate programs remain structured around disciplinary silos, limiting students' opportunities to develop these competencies prior to entering professional practice [4].

Educational research emphasizes the fact that authentic, project-based learning environments are necessary to bridge the gap between academic preparation and professional expectations. Interdisciplinary and service-based learning projects have been shown to improve student engagement, deepen conceptual understanding, and foster professional skills that are difficult to develop through traditional classroom instruction alone [5]-[7]. This paper presents a student project implemented within an upper-level Construction Project Management course working in coordination with an Electrical and Computer Engineering Technology course that integrated interdisciplinary collaboration, service-learning, and emergent project constraints to examine student learning related to adaptability and resilience.

2. Project Context and Course Setting

The project was implemented in CM 431, an upper-level Construction Project Management course within the College of Engineering and Technology at Western Carolina University. The project originated from an informal discussion regarding the need for a dedicated enclosure for a Boston Dynamics mobile robotic platform used on campus. This need was transformed into a competitive, service-based design–build project aligned with industry-relevant competencies [1], [8].

The winning doghouse would remain on campus for robotic operations, while those remaining would be donated to a local animal rescue organization. Prior research has shown that the presence of real stakeholders and tangible deliverables increases student accountability and strengthens professional identity development [6], [8]. The use of energy-efficient panelized construction systems introduced unanticipated system interactions related to charging efficiency and sensor-based docking, requiring the integration of engineering students to design environmental control and lighting systems. These evolving requirements closely mirrored professional AEC practice, where adaptability and resilience are essential [1], [9].

3. Educational Foundations

The instructional design of this project is grounded in established research in engineering education related to service-learning, interdisciplinary collaboration, and learning in environments subject to uncertainty and evolving requirements. These frameworks highlight the importance of 'real-world' systems-oriented learning opportunities that mirror professional engineering and construction projects.

Service-learning is widely recognized as an effective pedagogical approach for connecting academic content to real-world needs while promoting student engagement and professional responsibility. In engineering education, service-based projects have been shown to enhance motivation, deepen conceptual understanding, and improve teamwork and communication skills. Especially when students are accountable for delivering solutions to external stakeholders rather than 'academic' assignments [6], [8]. Empirical studies indicate that project-based service-learning environments support measurable gains in technical competence and professional skill development by requiring students to integrate theory with practice in the open-system environments where projects unfold [8].

Interdisciplinary collaboration supports these learning outcomes by exposing students to diverse perspectives and requiring them to reconcile differing assumptions, perspectives, and priorities. Research in AEC education shows that interdisciplinary learning improves students' ability to define requirements, manage ambiguity, and address complex problems that cut across disciplinary boundaries [2], [7]. Such experiences more closely reflect professional AEC practice, where successful project outcomes depend on effective coordination among multiple technical domains rather than isolated disciplinary expertise.

Beyond collaboration, this project is underpinned by research on adaptive skill and resilience in engineering problem solving. Engineering studies rarely involve static or fully defined statements of requirements; instead, AEC professionals must respond to evolving constraints, emergent system interactions, and dynamic stakeholder needs. Studies show that ambiguity and evolving requirements can promote deeper understanding, improved judgment, and more flexible reasoning strategies [10]. Educational models emphasizing systems thinking further highlight the importance of preparing students to recognize interdependencies among technical, organizational, and operational systems, particularly in complex project environments [10].

Finally, research on team learning underscores that resilience is not solely an individual attribute, but a collective capability supported by purposeful collaboration and open communication. Teams that foster this type of environment are more likely to engage in productive dialogue, surface uncertainties, and adapt effectively when confronted with unexpected challenges [11], [12]. By structuring the project to require iterative coordination between construction management and engineering technology students, while incorporating real stakeholders and performance consequences, the instructional design supported these behaviors.

4. Project Design and Implementation

The doghouse that would be staying on campus to house SPOT (Boston Dynamics robotic dog) would need lighting so SPOT could ‘see’ the AprilTag to position and dock with the charging apparatus as well as temperature control in the doghouse to maintain efficient charging conditions. The CM students approached the ECET students as a ‘specialist supplier’ to help them to address these requirements. The use of sustainable and energy-efficient material was another focus area, and the students worked with the manufacturer, Eco-Panels, for the walls and roof. These panels provide a higher R-Factor than standard frame construction (R-Factor is a material’s ability to resist heat flow) and would be a benefit for the doghouses being donated for animal rescue. For SPOT, these panels provide noise reduction while it is charging but create the potential for overheating the charging station. This created the need for temperature control and the opportunity for interdisciplinary collaboration with ECET students.

During the pre-construction portion of the project, the students faced several challenges requiring them to modify their initial designs. A change in the ‘owner’s’ requirements necessitated revising the original design, where the walls, roof, and floor formed a single integrated structure into a system capable of disassembly and reassembly. Subsequent material procurement timing constraints imposed by the manufacturer required the use of standard panel sizes, prompting a redesign around a common core structural system while preserving opportunities for creative exterior finishes. In parallel, students coordinated fabrication and assembly activities within a shared laboratory space, scheduling work around other academic courses. These evolving technical and logistical constraints closely mirrored professional practice and required students to demonstrate resilience, teamwork, and adaptive problem-solving. Throughout the semester, multiple assignments in each class were tied to the project.

4.1 CM 431 Construction Project Management:

CM 431 introduces students to construction project management and aligns project-based service-learning opportunities with the course content. This approach connects classroom theory to real-world community needs across the full project development cycle, from concept development through commissioning and handover. Students apply principles of risk management, project control, and site management while developing leadership, teamwork, and problem-solving skills on projects that deliver tangible community impact. Structured reflection is another aspect of the course, deepening academic understanding while fostering civic and social responsibility, ethical reasoning, empathy, and professional self-confidence.

The completion of the doghouses by a date necessitated by the availability of the external judges was the CM students' main project deliverable. During the semester, the project development was in harmony with the course lecture content. The following are the development steps followed for the construction of the doghouses:

1. Create project teams (professor-directed with no more than 6 members), roles, and Project Charter
2. Clearly define customer requirements
3. Using Building Information Modeling (BIM), create the team's conceptual design proposal
4. Design review with owner's "engineer" (member of the faculty)
5. Finalize design
6. Create project materials list, budget and schedule
7. Create supply-chain management plan (specialist suppliers and standard material suppliers)
8. Create Risk Management and Project Control Plan
9. Construction operations and quality management
10. Final inspection, commissioning, and handover

The course lectures followed the PMI project development steps and the students developed their work in this manner: Identify stakeholders and scope of work, design, procure, construct, handover to client. Timing varied as the 'client' specifications and materials specifications shifted during the early stage.

As this was an open design project, the limitations were set that students must use Eco-Panels for the walls and roof to keep the costs and optimal delivery time low. The other requirements were based on the Boston Dynamics SPOT requirements of space for docking. Additionally, the resulting design had to fit in the College IT Director's office. A prototype was built to test these limitations as well as thermal regulation of the space as SPOT charged. These limitations were considered by the CM teams when designing their doghouses.

4.2 ECET 431 Microcontroller Interfacing:

The ECET course is the second microcontroller course in the Electrical and Computer Engineering Technology program. Although the course topics are focused on more advanced hardware and software than required for this particular project (such as RTOS on 32-bit processors), for brevity, students were encouraged to use Arduino-based controllers in their designs. The learning objectives in this course were focused more on creative design, development, and presentation.

The ECET students were required to submit two main assignments for this project. While the reports and final technical details were reserved for the professor, crowdfunding-like videos were presented to the "customer" (the CM teams).

In week 4 of the semester, CM students presented the project requirements to the ECET class. The team leads of each of the CM groups explained expectations and requirements with a PowerPoint, then created a Discord channel to allow students from each class to communicate freely and asynchronously.

In week 6, ECET students were required to submit an initial report describing their team's ideas for triggering the lights and the control system for temperature regulation. This helped the professor see the scope of the projects and to know what parts might need to be ordered. This assignment required a hardware table, a high-level circuit sketch, and pseudocode.

In week 9, ECET students submitted their final project dossier, which included

1. A finalized Bill of Materials (BOM) that would be required for this design, as some designs evolved from the initial proposals over the weeks.
2. Updated high-level circuit sketch
3. Fully tested working code
4. Link to a crowdfunding-style video

Since most students were unfamiliar with video editing software and techniques, they were provided with multiple software options, tutorials on basic editing techniques, and they were encouraged to utilize Large Language Models (LLMs) to provide graphics and video clips.

Only the crowdfunding-style video was shared with the CM teams to allow them to select the winning design. In week 10, the CM students announced the winning electrical design. This allowed the winning team two weeks to prepare a demonstration board showing the fully implemented design. In week 12, the large event in which judges selected the winning SPOT robot house occurred. There were two winning designs: one for SPOT and another for the most architecturally elegant design.

5. Selection of Final Designs

Selection of the final designs was performed in two steps. First, the team leads of the CM groups chose the Electrical design that best fit their needs. Secondly, the external judges selected which doghouse structure best fit the needs for SPOT.

5.1 Electrical Control System Selection

Each of the ECET student teams submitted video clips of their proposed solutions for the CM students to evaluate. A rubric was developed to assess each of the ECET student proposals using functionality, temperature control, artificial lighting, manual override capability, and innovation as the evaluation criteria. Contractor proposal submission, evaluation, and award are foundational practices in the AEC industry. This activity provided both ECET and CM students with an experiential learning opportunity to effectively implement both inter- and cross-disciplinary communication, cooperation, and the development/interpretation of technical requirements and selection criteria. The rubric is provided in Appendix A.

5.2 Role of External Judges

A unique feature of this competition was the mixture of external judges and non-instructor stakeholders. This group included representatives from Boston Dynamics (SPOT manufacturer), the owner of Eco-Panels (the firm providing construction materials), and the director of the non-profit partner (Sarge's Animal Rescue). Additionally, there were two internal judges from the College of Engineering: the Assistant Dean and the Director of IT. The construction management competition rubric was used by these external judges to evaluate competing designs and to select the winning design for actual use on campus.

5.3 Alignment with Learning Objectives

The assessment framework was explicitly aligned with the project's learning objectives, including:

- Interdisciplinary collaboration between construction management and engineering students
- Systems thinking and integration of physical and operational constraints
- Adaptability and resilience responding to evolving project requirements
- Professional communication and accountability to external stakeholders

6. Results and Discussion

6.1 Engineering System Performance Outcomes

With regard to the selection criteria rubric, some ECET teams demonstrated more robust approaches to temperature regulation and lighting control. These teams accounted for interactions between thermal conditions, charging efficiency, and sensor activation logic, and often incorporated feedback mechanisms (such as LCD screens) or manual overrides to manage uncertainty. In contrast, lower-performing teams frequently treated temperature control and lighting as simple, isolated features, resulting in systems that functioned under limited conditions but failed to respond reliably to operational sequences or boundary cases identified by the construction management students judging the proposals.

6.2 Construction Management Performance Outcomes

Traditionally project management success was viewed as delivering a quality product by effectively managing time, cost, and scope. However, presently in the project domain this ‘triangle’ has been replaced by a pentagonal framework that encompasses quality and performance, schedule, socio-political environment, HSE (health, safety & environment), and cost. The student doghouse teams met the schedule to have the judging at the time required by the external judges, met the ‘owner’ requirement for SPOT as well as positively benefited the community partner, utilized sustainable materials, met the budget and all the projects met the quality requirements.

7. Lessons Learned and Transferability

7.1 Effective Achievements

This project was an effective method of encouraging students from different disciplines to interact with one another, providing a real-world example of client/designer interactions, and incorporating a service-learning opportunity. The multidisciplinary interactions were framed in an authentic client/contractor experience. The use of external judges from Boston Dynamics, Eco-Panels, and Sarge’s Animal Rescue was an added incentive that helped motivate the students

7.2 Changes

This project began as a CM project and only later pivoted to include the ECET students after the start of the semester. For similar projects in the future, the timing and focus of the Microcontroller Interfacing class topics would be modified to integrate the project more cohesively into the curriculum, rather than as an additional concurrent set of assignments to the standard lab curriculum. However, the emergent nature of project opportunities may not always align with semester planning.

The decision to utilize Arduino-based designs over the STM32-based boards was a strategic pedagogical choice to maintain both the momentum of the project and the sequence of topics covered in the microcontroller course. Students could begin work immediately due to their familiarity with Arduino from previous courses. As this project ran concurrently with other labs in the course, it was infeasible for students to utilize the same hardware. The use of Arduino boards allowed students to build and test a design over multiple weeks without having to tear it down for use in other lab assignments. Additionally, the ECET course focuses on C-programming and the Hardware Abstraction Layer (HAL) in the STM32 ecosystem. Students would not yet cover the necessary peripheral protocols for some of the sensors and displays they were allowed to use based on the timeline for the project. In future implementations of this project, the course topics could be rearranged to introduce these topics earlier and more cohesively include this project.

8. Conclusion and Further Work

8.1 Conclusions

This paper examined an interdisciplinary, service-based design–build project implemented across an upper-level Construction Project Management course and an Electrical and Computer Engineering Technology course. The project setting was in 'real world' setting characterized by evolving requirements, stakeholders, and tangible performance consequences. This approach effectively supported student learning related to interdisciplinary collaboration, systems thinking, adaptability, and resilience which are competencies necessary for successful professionals in the AEC industry.

The challenges highlighted in this paper were effectively dealt with by the student's resilience and teamwork skills. The teams had to revisit assumptions, adjust designs, and incorporate redundancy or manual overrides as the 'owner's' requirements became better understood. These behaviors align with educational research emphasizing adaptive expertise and judgment in complex, ill-structured problem environments. The combination of interdisciplinary coordination, service-learning accountability, and evolving constraints created conditions that closely mirrored professional AEC practice, reinforcing the value of such pedagogical approaches in undergraduate engineering and construction education. Overall, the project demonstrates that interdisciplinary, service-based learning environments, when aligned with assessment criteria emphasizing integration and real-world performance, can support the development of professional behaviors associated with adaptability, resilience, and systems thinking.

8.2 Further Work

The project model described in this paper offers a transferable framework that could be adapted to other engineering and construction contexts, including infrastructure, sustainability-focused projects, or emerging technology integration. One particular area of interest is the ability to identify opportunities to utilize technology such as AI, sensors, sustainable materials, and robotics to address the need for affordable housing.

This project has demonstrated that interdisciplinary, service-based projects represent a fertile area for continued innovation and research in engineering and construction education. Projects like SPOT's doghouse can play a critical role in preparing graduates for the complexity, uncertainty, and collaborative demands of the future professional practice while at the same time reminding them that contributions to local communities is both a necessary human and professional activity.

Finally, this project was well received by a broad audience. The local ABC affiliate, WLOS Asheville, covered the judging and winning team announcement event on campus [14]. Also, the views on the College of Engineering's Instagram account increased 134%, and the reach increased by 221%, with similar impacts on Facebook. This level of response helps reinforce the value of the students' efforts and increases their interest in getting involved in similar projects in the future.

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Appendix A: Rubric for Selecting the ECET Control System

SPOT Sensor Engineering Competition Judging Criteria

	Proficient *20 Points*	**Emerging** *15 Points*	**Beginning** *10 Points*
Functionality	Pitch was clearly thought out to meet all of SPOT's needs	Pitch met some of SPOT's needs, no manual override included	Was not functional for SPOT's needs
Temperature Control	Pitch clearly demonstrated how the sensor would meet SPOT's temperature requirements, and energy efficiency was taken into account	Pitch demonstrated how SPOT's temperature control requirements would be met, energy efficiency not taken into account	Pitch did not effectively meet SPOT's temperature control requirements
Artificial Lighting	Pitch demonstrated how the sensor would meet SPOT's lighting requirements, and energy efficiency was taken into account.	Pitch demonstrated how SPOT's lighting requirements would be met, lack of energy efficiency	Pitch did not meet SPOT's temperature control requirements
Manual Override	Pitch for sensor included manual override switch for system if needed	Pitch for sensor demonstrated possible override switch for system	Pitch did not include manual override switch for system
Innovation	Pitch was unique, organized, and well thought out to meet the needs for SPOT	Pitch used little innovation, but met needs for SPOT	Pitch was unorganized, lacked creativity, and did not meet SPOT's needs

Appendix B: Rubric External Judges Used to Select Doghouse

Rubric: Boston Dynamics Robotic Doghouse Design-Build Competition CM 431 Class

Category 1: Aesthetics and Functionality

Criteria	Description	Excellent	Good	Satisfactory	Comments
Overall Aesthetic Appeal	Visual harmony, proportion, and creativity of the doghouse design.				
Innovation in Design	Unique or thoughtful design elements that make it stand out (shape, materials, finishes, integration with robotics theme).				
Craftsmanship & Detailing	Quality of construction, precision of joints, finishing, and material selection.				
Fit & Access	Adequate size, clearance, and ease of access for the Boston Dynamics robot.				
Structural Stability & Durability	Sound construction techniques and weather resistance appropriate for the intended use.				

Rubric: Boston Dynamics Robotic Doghouse Design-Build Competition CM 431 Class

Category 2: Presentation and Reflection

Criteria	Description	Excellent	Good	Satisfactory	Comments
Presentation Clarity	Clear, engaging explanation of concept, process, and design rationale.				
Learning Reflection	Team demonstrates thoughtful reflection on what they learned about construction management, collaboration, and problem-solving.				
Challenges & Solutions	Team identifies key challenges (technical, logistical, interpersonal) and explains how they overcame them.				

Category 3: Community Impact

Criteria	Description	Excellent	Good	Satisfactory	Comments
Consideration for Donation Use	Design adaptability and appropriateness for use as a shelter for rescue animals.				
Sustainability & Material Stewardship	Responsible use of donated materials and consideration of environmental impact.				

Suggested Judge Questions for Team Reflection

1. What was the biggest design or construction challenge your team faced, and how did you resolve it?
2. How did your team manage the project timeline and allocate responsibilities?
3. What did you learn about construction project management through this hands-on build?
4. How did you incorporate the robot's functional needs into your design decisions?
5. What would you do differently if you had to start the project again?