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Future-Focused:

Educating in an Era of Continuous Change

Makerspace integration into curriculum

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Preparing future engineers requires moving beyond traditional, siloed teaching methods toward approaches that build adaptability, resilience, interdisciplinary collaboration, and development of a robust engineering identity. However, many first-year engineering courses still emphasise theoretical content over practical, real-world skills. In response, this paper presents a food delivery robotics project co-developed by the School of Electrical Engineering and Telecommunications and UNSW Makerspace as a case study in curriculum design and innovation. The project uses hands-on learning, iterative skill-building, and a modular arena to engage students in authentic engineering challenges. By embedding experimentation, failure, and teamwork into the learning process, the initiative fosters a growth mindset and mirrors the collaborative nature of the engineering profession. This paper outlines the challenges and solutions involved in integrating Makerspace practices into the curriculum and highlights how such approaches can better prepare students for the evolving demands of the profession. The success of this initiative underscores the potential of interdisciplinary, practice-based education in cultivating the next generation of agile, industry-ready engineers.

Keywords: Engineering Design, First-year engineering, Makerspace

1. Introduction

"If we teach today's students as we taught yesterday's, we rob them of tomorrow."
– John Dewey

More than a century ago, educational reformer John Dewey advocated for experiential learning — an approach that places experience, reflection, and active problem-solving at the heart of education (Dewey, 1986). His ideas remain profoundly relevant today. The world engineers are stepping into is evolving faster than ever, demanding not only deep technical skills but also creativity, adaptability, and the ability to collaborate across disciplines. Traditional, discipline-siloed teaching models, once sufficient, now risk leaving graduates unprepared for the complex, interconnected nature of modern society — a challenge increasingly addressed through innovations like the Vertically Integrated Projects (VIP) model, which fosters long-term, multidisciplinary collaboration and sustained engagement across institutional boundaries (Amoo et al., 2020).

At UNSW, Project-Based Learning (PBL) is embedded from the first year through to final-year capstone courses. Flagship examples include the first-year DESN1000: Introduction to Engineering Design and Innovation and the second-year variant DESN2000: Engineering Design and Professional Practice, where students work in teams to solve open-ended design problems. Beyond the classroom, the UNSW's ChallENG program offers co-curricular, student-led projects that integrate industry, innovation, and teamwork — from building solar-powered cars with sUNSWift, to developing autonomous soccer-playing robots in rUNSWift, to designing wearable health technologies and sustainable energy systems in developing countries.

The UNSW Makerspace plays a key role in providing students with advanced prototyping tools and technical support. While traditionally supporting extracurricular activities, there is growing momentum to embed Makerspace practices within the curriculum. Doing so in large, interdisciplinary cohorts requires careful coordination around safety, access, skill development, and alignment with learning outcomes. Yet the benefits are substantial: hands-on, design-led learning enhances engagement, iterative thinking, and practical confidence, while also fostering creativity, identity formation, and interdisciplinary collaboration (Carnasciali, Gillespie, & Hossain, 2021; Lagoudas et al., 2016; Taheri, Robbins, & Maalej, 2019).

This approach also supports sustainability by enabling shared use of tools and project reuse, while equipping students with resilience, systems thinking, and collaboration skills essential for modern engineering practice. Within the broader DESN1000 curriculum, this paper highlights a modular robotics project led by the School of Electrical Engineering and Telecommunications in partnership with the Makerspace. The project fosters hands-on, interdisciplinary engagement and addresses key implementation challenges, creating a scalable and sustainable learning model. The following sections outline its design, implementation, and methodology.

2. Curriculum-Integrated Makerspace: What It Means and Why It Matters

A curriculum-integrated Makerspace embeds design-led, hands-on learning—supported by Makerspace tools—directly into course content, assessments, and timetables. This ensures all students engage in prototyping, iteration, and tool-based problem solving as a formal part of their education, developing practical skills and interdisciplinary collaboration experience essential for contemporary engineering practice.

Despite its relevance, many engineering programs remain dominated by theory, offering limited access to authentic, tool-based learning. In response, courses such as DESN1000 have begun integrating Makerspace projects to modernise the curriculum and provide meaningful, project-based learning experiences. However, embedding these activities into large, multi-stream courses presents substantial challenges related to curriculum alignment, assessment design, student preparedness, and the logistics of safe and equitable access to resources. These challenges—outlined in Table 1—emerged during the development of a first-year modular robotics project co-led by engineering educators and UNSW Makerspace staff.

To address these complexities, we adopted an iterative, multifaceted approach: aligning Makerspace activities with learning outcomes, implementing scalable assessment frameworks, and providing time for design iteration. Student support is scaffolded through mentoring, targeted skill development, and structured team collaboration, while staff training and robust safety protocols ensure effective delivery at scale. Together, these strategies create a sustainable model for integrating Makerspace learning that prepares students to meet evolving technological and societal demands.

Table 1: Challenges in integrating a multidisciplinary Makerspace project into DESN1000.

Theme	Challenge Area	Key considerations and practical implementation
Curriculum Integration	Curriculum Alignment	Ensuring activities support learning outcomes and align with formal assessments.
	Time Constraints	Managing limited contact hours while allowing for iteration and design freedom.
	Assessment Design	Developing fair, transparent, and scalable rubrics that accommodate open-ended, team-based outputs and diverse deliverables.
Student Experience	Skill Level Variation	Addressing differing levels of experience with tools, programming, and teamwork.
	Team Dynamics	Supporting effective cross-disciplinary collaboration in large cohorts.
	Student Support & Feedback	Providing timely and meaningful feedback while ensuring students have access to adequate guidance, mentorship, and emotional support throughout the project.
Delivery & Logistics	Staff Training & Support	Equipping demonstrators and staff with the multi-disciplinary skills to supervise tool-based, interdisciplinary work.
	Safety & Logistics	Managing safe access to tools, bookings, and lab procedures across a large cohort.

3. Modular Solution to Makerspace Integration

Large cohort sizes demand a course design that is pedagogically effective, scalable, and sustainable. To address this, the project was built around a modular, future-proof structure that can be easily adapted or reused across offerings. The physical infrastructure—including durable yet lightweight project arenas—supports flexible deployment and everyday use.

Key technical components, such as screens and electronic kits, are demountable to enable customization across courses and engineering streams. Coordinating mechanical, electrical, and computing disciplines ensures cross-disciplinary relevance, optimises resources, and strengthens faculty-wide technical support. This integrated model fosters interdisciplinary collaboration and creates a resilient educational environment suited for large-scale curriculum delivery. The Modular Food Delivery Robotics Project engages first-year students in cross-disciplinary teams to design, prototype, and test semi-autonomous robots within a modular arena. Grounded in engineering design principles (Dym et al., 2013), it promotes iterative problem-solving that balances client needs with real-world constraints.

3.1 Arena design and makerspace collaboration

At the centre of the project is a modular, reconfigurable arena co-developed with the Makerspace team. Constructed from lightweight, interlocking foam tiles, the arena is designed for easy transport and rapid deployment across teaching labs. The arena is shown in Figure 1. Modular inserts — including ramps, delivery zones, and custom pathways — allow for quick reconfiguration each term, enabling new design objectives without a complete redesign. This collaborative design supports integration into other courses and outreach events, enhancing its educational and logistical value.

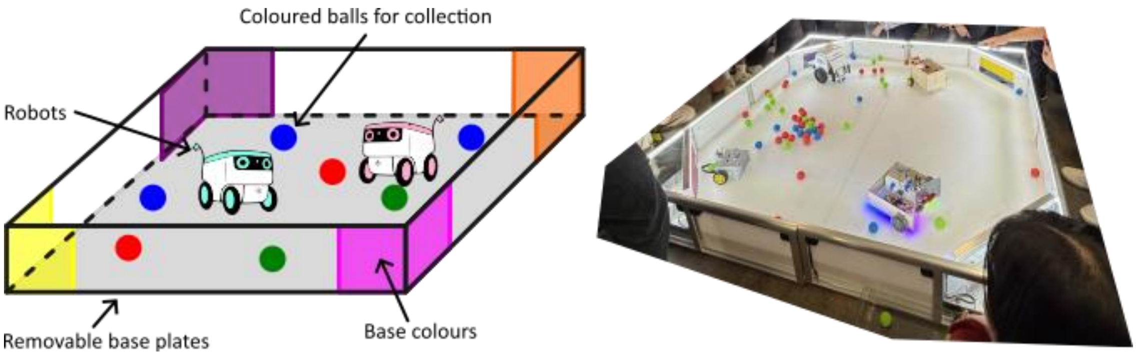

Figure 1: Illustrated of the modular arena (left) and image of the actual modular arena (right).

3.2 Makerspace integration and support

Beyond the arena, the Makerspace plays a critical role in project delivery by offering fabrication tools, modular prototyping kits, and technical support. This hands-on environment empowers students to experiment and iterate quickly, while promoting equitable access to resources, interdisciplinary teamwork, and sustainable practices through the reuse of components and shared facilities.

3.3 Custom robot kits

Each team receives a standardised robot kit comprising a mechanical chassis, microcontroller, motors, IR and ultrasonic sensors, and modular power components. Designed for flexibility and accessibility, the kits support demountable electronics and encourage independent subsystem development. While the base kit ensures equity, students can expand functionality with additional components. Future iterations will explore features such as vision-based navigation and centralised pathfinding to support more advanced design challenges.

3.4 Curriculum integration across disciplines

The project is tightly scaffolded across mechanical, electrical, and computing streams (Lee et. al., 2024). Students build foundational skills by learning circuitry and motor control, advance through sensor programming and logic development, and finally design and fabricate a robust chassis using CAD and Makerspace tools. This systems-based approach fosters a holistic understanding of engineering design. This integration is illustrated in Figure 2, which outlines how the movement subsystem is scaffolded across electrical, mechanical, and computing disciplines.

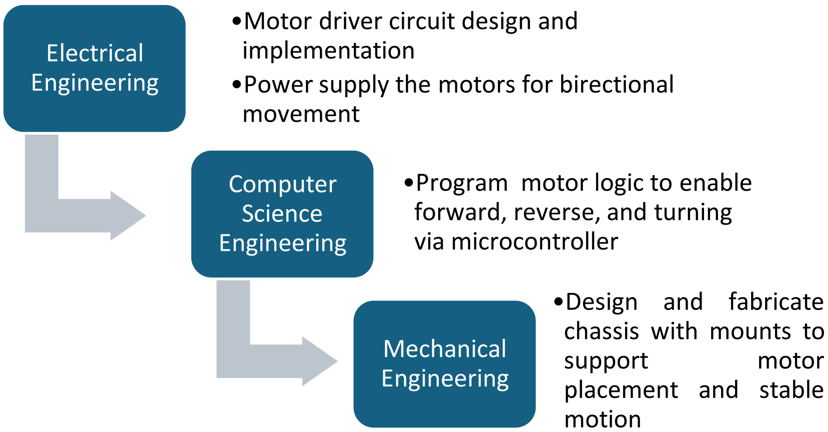

Figure 2: Cross-disciplinary scaffolding of the movement subsystem across multiple disciplines.

3.5 Student outcomes and engagement

Student perspectives were gathered through informal observations and reflections conducted by staff during project activities. These insights helped guide iterative refinements to both the robotics project and the integration of Makerspace resources into the curriculum. Feedback has been overwhelmingly positive, with students demonstrating resilience, creativity, and problem-solving skills as they navigated technical and collaborative challenges, managed tasks, justified design decisions, and presented their outcomes. These experiences provide a strong foundation for future engineering practice, where communication and adaptability are valued alongside technical expertise. Future studies will incorporate formal qualitative and quantitative data collection through surveys and structured assessments to more systematically evaluate student learning outcomes.

4. Curriculum Design to Project implementation

The implementation of the Modular Food Delivery Robotics Project was carefully designed to address the pedagogical, logistical, and experiential challenges associated with delivering a large-scale interdisciplinary project in a first-year setting. The following outlines the project's strategic responses across curriculum integration, student experience, and logistical delivery.

4.1 Outcomes and Reflections

Student feedback has been overwhelmingly positive. Participants expressed pride in their tangible achievements and valued their hands-on experience with Makerspace tools and environments. Many reported increased confidence in prototyping and fabrication, leading them to independently return to Makerspace facilities for personal projects and further skill development. This reflects a shift from passive learning to active engagement, demonstrating the project's success in fostering not only technical skills but also a sense of ownership and belonging within the engineering community.

The modular, scaffolded design and integrated support structures have proven effective in managing scale and complexity while maintaining educational quality. The project's iterative, hands-on approach encouraged students to navigate technical and collaborative challenges, make design decisions, and reflect on outcomes—practices that closely mirror professional engineering work. Its structure and delivery demonstrate how large-scale, interdisciplinary projects can be embedded in first-year courses in ways that are both manageable for staff and highly engaging for students. This model offers practical insights for implementing similar experiential learning initiatives across diverse engineering curricula, supporting the development of collaborative, adaptable, and resilient graduates.

Table 2: Solutions implemented to address key challenges in the delivery of the Modular Food Delivery Robotics Project across curriculum, student experience, and logistics.

Theme	Challenge Area	Solution Implemented
Curriculum Integration	Curriculum Alignment	Project milestones were directly mapped to weekly content in circuits, programming, and CAD, ensuring every activity reinforced course learning outcomes.
	Time Constraints	The modular arena and subsystem-based kits allowed for incremental, achievable tasks within limited contact hours. Multiple testing sites maximised flexibility.
	Assessment Design	Developed flexible rubrics focusing on process, collaboration, and problem-solving, with peer/team components.
Student Experience	Skill Level Variation	Foundational workshops and scaffolded resources (guides, videos) ensured all students could participate confidently, while rotating team roles encouraged skill-sharing.
	Team Dynamics	Early team-building exercises, mentor check-ins, and peer reviews promoted collaborative accountability, helping students navigate teamwork in large cohorts.
	Student Support & Feedback	Provided continuous formative feedback via weekly check-ins and embedded mentor support in lab sessions.
Delivery & Logistics	Staff Training & Support	Cross-disciplinary demonstrators received structured training and support materials. Makerspace staff provided consistent oversight and technical guidance.
	Safety & Logistics	Makerspace's badging system, inductions, and booking protocols ensured safe, equitable access to equipment—scaling responsibly without compromising safety.

5. Conclusion

Integrating Makerspace capabilities into DESN1000 advances first-year engineering education by providing equitable access to prototyping tools, fostering interdisciplinary collaboration, and embedding sustainable design practices. This hands-on, project-based approach addresses common challenges in large courses while developing essential skills and an innovation-focused mindset. Looking ahead, the model offers a scalable framework for other programs aiming to blend sustainability with practical experience, preparing students to meet future engineering challenges and drive positive impact through creative, collaborative solutions.

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