

Challenge-Based Learning Project using ExoMy Mars Rover for undergraduate engineering students in Ireland

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Abstract— *This paper presents an innovative Challenge-Based Learning (CBL) project undertaken by four undergraduate Mechanical and Manufacturing Engineering students from the REEdI (Rethinking Engineering Education in Ireland) program at Munster Technological University (MTU), Tralee. The project involved the fabrication, assembly, and programming of an ExoMy Mars Rover—a scaled-down, open-source robotic platform originally developed by the European Space Agency (ESA) as an educational analogue to the ExoMars rover. Students were tasked with interpreting ESA's technical documentation, 3D printing over 40 custom components, sourcing electronic hardware, and integrating mechanical and software systems to produce a fully functional rover. The project emphasized multidisciplinary skills, combining additive manufacturing, mechanical assembly, electronics integration, and Python-based programming for autonomous navigation. This hands-on approach aligned with CBL principles by engaging students in a real-world engineering challenge that required problem-solving, collaboration, and iterative design. Feedback collected from the students indicated high levels of engagement and satisfaction. Students highlighted the tangible nature of the project, the opportunity to apply theoretical knowledge in a practical context, and the development of transferable skills such as teamwork and project management. Key lessons learned included the importance of early risk assessment for component tolerances, effective time management during iterative prototyping, and the need for clear documentation when adapting open-source designs. The project demonstrates the innovative potential of CBL in engineering education by leveraging space exploration themes to inspire creativity and technical competence. It also underscores the value of integrating emerging technologies—such as 3D printing and robotics—into undergraduate curricula to prepare students for Industry 4.0. Future iterations will explore enhanced autonomy and sensor integration, further enriching the learning experience.*

Keywords— *Challenge-Based Learning (CBL), ExoMy Mars Rover, Additive Manufacturing, Engineering Education Innovation, Multidisciplinary Project-Based Learning.*

I. INTRODUCTION

Engineering education is undergoing a paradigm shift, moving away from traditional lecture-based approaches toward active, experiential learning models that better prepare graduates for the demands of Industry 4.0. Among these models, Challenge-Based Learning (CBL) has emerged as a powerful framework that engages students in solving real-world problems through collaborative, multidisciplinary projects. CBL emphasizes critical thinking, creativity, and practical application of

theoretical knowledge, aligning closely with the skills required in modern engineering practice.

This paper explores the implementation of a CBL project within the REEdI (Rethinking Engineering Education in Ireland) program at Munster Technological University (MTU), Tralee. The REEdI initiative seeks to transform engineering education by integrating innovative pedagogical strategies and industry-relevant challenges into the curriculum. As part of this vision, a group of four undergraduate Mechanical and Manufacturing Engineering students undertook a unique pilot project: the design, fabrication, assembly, and programming of an ExoMy Mars Rover, an open-source robotic platform developed by the European Space Agency (ESA) as an educational analogue to its ExoMars rover.

The project required students to interpret ESA's technical documentation, 3D print over 40 custom components, source electronic hardware, and integrate mechanical and software systems to produce a fully functional rover. Beyond technical execution, the challenge demanded effective teamwork, time management, and iterative problem-solving—hallmarks of CBL methodology. By leveraging additive manufacturing, robotics, and Python-based programming, the project provided a multidisciplinary learning experience that has helped the students bridge theory and practice for their course.

The innovative nature of this undertaking lies in its thematic connection to space exploration, a domain that inherently inspires curiosity and creativity. Furthermore, the project introduced students to emerging technologies and collaborative workflows, fostering competencies essential for future engineers. Student feedback collected throughout the project revealed high engagement and satisfaction, with participants citing the tangible, hands-on nature of the task as a key motivator. Lessons learned included the importance of tolerance control in 3D-printed components, early risk assessment, and clear documentation when adapting open-source designs.

This paper discusses the project's objectives, methodology, outcomes, and student reflections, highlighting its contribution to engineering education innovation. It also examines the broader implications of integrating CBL and open-source platforms into undergraduate curricula, offering insights for educators seeking to enhance experiential learning in STEM disciplines.

II. LITERATURE REVIEW

Engineering education has traditionally relied on lecture-based instruction [1], but the growing complexity of modern engineering challenges has driven a shift toward active learning methodologies [2]. Problem-Based Learning (PBL) emerged as one of the earliest approaches to address this need, emphasizing student-centered learning through the resolution of open-ended problems [3]. PBL encourages learners to identify knowledge gaps, research solutions, and apply theoretical concepts in practical contexts [4]. Studies have shown that PBL enhances critical thinking, self-directed learning, and collaborative skills, making it a valuable pedagogical tool in engineering curricula [5].

However, while PBL focuses on solving predefined problems, it often lacks the broader societal or real-world context that motivates students to engage deeply with the challenge [6]. To address this limitation, Challenge-Based Learning (CBL) has evolved as an extension of PBL [7], incorporating authentic, multidisciplinary challenges that connect classroom learning to global issues [8]. CBL emphasises iterative design, teamwork, and the integration of diverse skill sets, fostering creativity and innovation [9]. Research indicates that CBL not only improves technical competence but also cultivates communication, leadership, and adaptability—skills essential for Industry 4.0 [10].

Robotics platforms have become increasingly popular in implementing experiential learning strategies such as PBL and CBL [11]. Robotics projects provide tangible, hands-on experiences that bridge theory and practice, motivating students through interactive problem-solving [12]. Common platforms like LEGO Mindstorms and Arduino-based systems have been widely adopted to teach principles of mechanics, electronics, and programming [13,14]. These projects often serve as capstone experiences, reinforcing multidisciplinary integration and teamwork [15].

The ExoMy Mars Rover, developed by the European Space Agency (ESA), represents a novel educational tool within this context [16]. As an open-source, 3D-printable rover inspired by the ExoMars mission, ExoMy offers students an opportunity to engage with space exploration themes while applying advanced engineering concepts [17]. Its design requires proficiency in additive manufacturing, mechanical assembly, electronics integration, and Python-based programming, making it ideal for CBL initiatives. Previous studies highlight the motivational impact of space-related projects in STEM education, noting their ability to inspire creativity and sustain engagement [18].

Despite the growing adoption of robotics in education, literature on integrating open-source platforms like ExoMy within CBL frameworks remains limited. Existing research primarily focuses on traditional robotics kits, leaving a gap in understanding how complex, mission-inspired projects influence learning outcomes and skill development [19]. This paper addresses this gap by examining the implementation of an ExoMy-based CBL project for undergraduate engineering students, analysing student feedback, lessons learned, and implications for curriculum innovation going forward.

III. METHODOLOGY

A. Project Context and Participants

This Challenge-Based Learning project was implemented within the Mechanical & Manufacturing Engineering undergraduate course on the REEdI program at MTU, Tralee, with a cohort of four second-year undergraduate students. A faculty facilitator and a mentor supported the team. The learning objectives targeted multidisciplinary integration (mechanical design and tolerancing, additive manufacturing, electromechanical assembly, and embedded programming), collaborative problem-solving, and professional skills (communication, documentation, and project management).

B. ExoMy Project Resources

The project leveraged the open-source ExoMy Mars Rover resources [16] originally released by the European Space Agency (ESA), is shown in Fig. 1. It includes Design assets (3D-printable STL files, assembly drawings/exploded views, and CAD references); Bill of Materials (BOMs e.g. suggested COTS components (motors, drivers, SBC/MCU, power system, sensors) with indicative specifications); Build guides (Step-by-step mechanical and electrical integration instructions, wiring diagrams, and calibration notes); a Software stack, including example firmware, controller scripts (e.g., Python/ROS variants where applicable), and configuration files for teleoperation and basic autonomy



Fig. 1 – The ExoMy 3D Printed Mars Rover Robot

These resources enabled the Mechanical/Manufacturing students to interpret technical documentation and drawings, adapt STL/CAD for printer constraints and tolerance control, plan procurement against the BOM, and integrate mechanical

assemblies with electronics and software in a structured workflow.

C. Project Phases

The first phase of the project was the “Challenge Framing & Planning” phase, in Week 1. Students defined the performance targets (mobility, steering, terrain negotiation, battery life) for the project, performed a risk assessment for print tolerances, lead times, and supply chain substitutions for the components involved. Task assignments were allocated and work breakdown structure (WBS), RACI, and sprint plans were created.

Phase 2 saw the project resources reviewer for fabrication readiness in week 2. A DfAM (Design for Additive Manufacturing) review of STL project files and pilot prints of tolerance coupons/final print profiles were carried out here.

The additive manufacturing & post processing of the project occurred in Phase 3 and lasted for 2 weeks. In this phase, the batch 3D printing of the 40+ component parts was realised, as shown in Fig. 2. Associated dimensional inspection with calipers/gauges was also conducted. Post-processing work saw activities such as support removal, deburring and light sanding carried out.



Fig. 2 - Component Parts for the ExoMy Rover Project after 3D Printing

The Mechanical Assembly & Electronics Integration of Phase 4 happened in Weeks 4–5. Subassemblies constructed included the wheel modules, suspension/rocker-bogie and the chassis. Electronics components such as motor drivers, SBC/MCU mounting, power distribution, cable management and EMI minimisation were included at this stage – Fig. 3 shows students working on this phase of the project. During this phase, the component alignments, backlash & friction points were also verified. Iterative reprints were done if needed.

Phase 5 involved the software, calibration & testing activities and covered weeks 6–7 of the project. Activities here included bringing up the control stack (motor mapping, PID tuning, joystick/teleop); sensor integration (e.g., IMU, camera) and basic autonomy (waypoint following/obstacle avoidance as stretch goals).

The final phase, phase 6, was the validation, demonstration & reflection phase in week 8. Deliverables included project demonstration against defined performance

targets; production of a technical report, bill-of-process (BOP), and maintenance guide for the completed system and a team reflection session and knowledge transfer activity.

The project followed an iterative design–build–test cycle, enabling progressive refinement of system performance across the multiple development stages/phases.

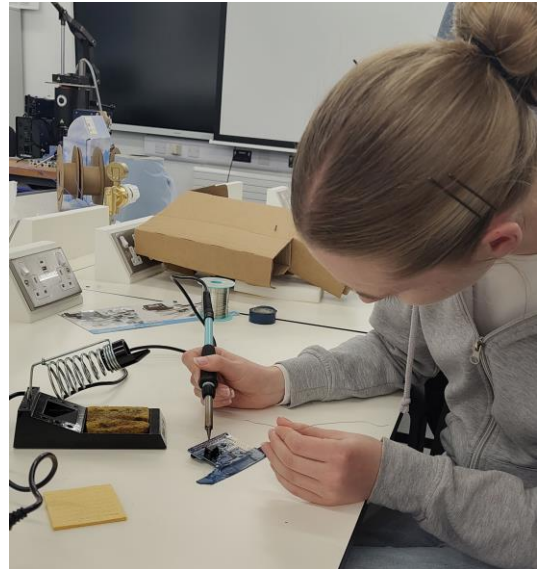


Fig. 3 - Student working on Phase 3 of the project

D. Tools and Infrastructure

The following tools and resources were utilised by the students in the completion of this CBL project: -

- Additive Manufacturing: FDM printers with 0.4 mm nozzles, PLA/PETG materials; slicers (Cura/PrusaSlicer).
- Metrology: Callipers, go/no-go gauges, tolerance coupons.
- Electronics: Soldering stations, benchtop Power Supply Unit (PSU), multimeter, oscilloscope (as available).
- Software: CAD viewer, version control (Git), Python, microcontroller IDE, ROS, Docker.
- Safety/Quality: Risk register, design reviews, EHS protocols.

Students were permitted to utilise AI-assisted tools for debugging and code development, reflecting contemporary engineering practice and emerging digital competencies.

E. Assessment Approach

Assessment combined product performance with process quality, emphasizing qualitative feedback from the students. Student reflections on decisions, challenges, and learning gains as well as guided discussions on teamwork, communication, and risk responses were utilised. For the observation & artefact review, rubrics for print quality, assembly craftsmanship, wiring standards, code readability, and documentation completeness were used. Table I presents a concise summary of the key assessment rubric dimensions

used to evaluate manufacturing quality, system integration, and overall rover performance. The demonstration rubric included features such as mobility, reliability, maintainability, and safety compliance.

TABLE I
EXAMPLE ASSESSMENT RUBRIC DIMENSIONS

Criterion	Indicator
Print Quality	Dimensional accuracy, surface finish
Assembly Quality	Alignment, fastening integrity, mechanical function
Electronics Integration	Wiring standards, reliability, safety
Software	Code functionality, structure, debugging capability
Demonstration	Mobility, reliability, system stability

Findings from journals, facilitator notes, and focus groups formed the primary qualitative dataset, triangulated with artefact rubrics and demonstration outcomes to capture both learning processes and technical achievement.

Quantitative indicators such as component counts, project timelines, iterative reprint cycles, and demonstration performance criteria were documented to complement qualitative observations.

Table II summarises key project metrics and structured observations, including manufacturing scope, iterative development processes, and assessment dimensions, providing a concise overview of the implementation context.

TABLE II
SUMMARY OF OBSERVED IMPACTS OF LABORATORY INTERVENTIONS

Category	Metric	Observed Value / Description
Project Duration	Total duration	8 weeks
Manufacturing	Number of printed components	40+ parts
Manufacturing Iteration	Reprint requirement	Multiple iterative reprints required for tolerance and fit refinement
Assembly & Integration	Integration stages	Mechanical, electrical, and software integration completed in sequence
Testing	Validation phases	Functional testing (mobility, control, system integration) conducted in final phase
Performance	Rover functionality	Achieved baseline teleoperation; partial autonomy explored as

		stretch goal
Team Structure	Group size	4 students
Workflow	Iteration cycles	Repeated print–test–refine loops observed throughout development
Assessment	Evaluation approach	Rubric-based assessment (print quality, assembly, coding, documentation, demonstration)
Performance Evaluation	Navigation & autonomy	Baseline teleoperation achieved; partial autonomy explored

Performance criteria such as mobility, control responsiveness, and subsystem integration were defined qualitatively, with scope for future formalisation into measurable indicators (e.g., navigation accuracy, response latency, and system reliability metrics).

IV. DISCUSSION & FEEDBACK

A. Student Engagement and Learning Gains

project fostered high engagement by anchoring learning in an authentic, space-exploration context while requiring tangible deliverables across mechanical, electrical, and software domains. Students reported strong motivation from seeing rapid prototype-to-function transitions and from the narrative of building a Mars-rover analogue. The hands-on nature amplified ownership and persistence, particularly during troubleshooting of printed components and calibration cycles.

“It took us a few tries to get the print to come out good, one of the changes we made was slowing down the speed in which the part was being printed so it would be more accurate.”

“The servos caused considerable problems when trying to program them and set them up... this was achieved in the end however took considerable time.”

Beyond motivation, students demonstrated growth in systems thinking—linking DfAM choices (e.g., material, infill, tolerance) to downstream assembly and control performance. Reflective pieces indicated increased confidence in documenting design rationales and in conducting structured test-and-learn iterations. The project also catalysed soft skills: weekly stand-ups, Kanban tracking, and retrospectives encouraged accountability, concise technical communication, and collaborative decision-making.

B. Technical Challenge: Scope, Integration, and Risk

The project presented a calibrated level of difficulty for a four-student team, with peaks during (1) tolerance tuning for rotating/meshed parts, (2) electronics integration and cable management in a confined chassis, and (3) control bring-up (motor mapping, PID tuning, sensor fusion). Iterative reprints

were necessary when dimensional drift or anisotropy impaired fit, underscoring the importance of front-loaded DfAM reviews and tolerance coupons. Supply substitutions (motors, fasteners, connectors) occasionally required on-the-fly redesign of interfaces and updated BOM control.

“Within the body we discovered that the slot that was there was for the older part which wasn’t available and a newer model of the one set out from the original project was ordered... it doesn’t fit within the 3D desired spot so we needed to come up with a solution without changing the body... we used the screw holes that were in place and went into 3D CAD and came up with a piece that would hold the parts in place like it was originally planned for with the older model of the part.”

“Some of the cables provided weren’t long enough and had to be extended to reach the raspberry pi.”

Software complexity scaled with ambition: baseline teleoperation was attainable within time. A scaffolded approach and assistance from AI search engines such as ChatGPT and CoPilot proved invaluable to the students in debugging many of the software issues encountered in the development. Autonomy (e.g., independent movement, automatic control) introduced compounding dependencies (wireless communications, OS subroutines and sensor integration) which proved challenging for the hardware-orientated students. The use of version control and defect logs helped smooth progress, suggesting these should be mandated scaffolds in future cohorts.

From a technical perspective, the rover system achieved stable baseline operation, including reliable teleoperation, mechanical stability, and integrated subsystem functionality across mechanical, electrical, and control domains. Navigation performance at this stage was primarily manual, with partial implementation of autonomy features such as waypoint following explored as stretch goals. Key technical observations included sensitivity to tolerance variation in mechanical assemblies and challenges associated with sensor integration and software configuration. While full quantitative benchmarking (e.g., navigation accuracy, sensor precision, or response times) was beyond the scope of this pilot, the project established a functional platform and repeatable workflow that can support more formalised performance evaluation in future iterations.

The use of AI-supported tools (e.g., ChatGPT, Copilot) by students emerged as a notable feature of the project, particularly during software debugging and problem-solving activities. From a pedagogical perspective, this reflects an evolving learning dynamic in which AI tools function as on-demand and cognitive scaffolds, supporting iterative development and reducing barriers to entry in unfamiliar domains such as control programming. While these tools enabled students to

progress through technical challenges more efficiently, their use also highlighted the importance of developing critical evaluation skills, including interpreting AI-generated outputs, validating solutions, and maintaining conceptual understanding. Future iterations of the project could more explicitly integrate AI literacy into the learning design, including guidance on effective use, verification strategies, and reflection on the role of AI in engineering practice.

Although formalised before–after benchmarking of rover performance was not conducted in this pilot, iterative technical improvement was observed across multiple development cycles, as shown in Table III. Early prototype iterations exhibited issues related to dimensional tolerances, component fit, and control instability, requiring reprints and recalibration. Subsequent iterations demonstrated improved mechanical alignment, reduced friction, and more stable motion during teleoperation following refinement of print parameters and control tuning. Similarly, initial software configurations resulted in communication and control errors, which were progressively resolved through debugging and code adaptation, leading to more reliable system behaviour. These iterative improvements provide an implicit form of before–after comparison within the project lifecycle, highlighting the role of design-build-test cycles in developing both technical performance and student competence.

TABLE III
ITERATIVE TECHNICAL IMPROVEMENTS OBSERVED ACROSS
DEVELOPMENT CYCLES

Aspect	Early Stage (Initial Build)	Later Stage (Refined System)
Mechanical Fit	Tolerance mismatches; reprints required	Improved alignment; stable assemblies
Motion Control	Erratic behaviour; calibration issues	Smoother motion after PID tuning
Software	Configuration errors; debugging challenges	More stable teleoperation achieved
Integration	Wiring and component fit issues	Improved cable management and system integration
System Reliability	Intermittent functionality	Consistent baseline operation

C. Advantages and Disadvantages for a Sub-Cohort

Advantages of running the project with a focused sub-cohort (comprising of four students) as opposed to the entire student group included closer facilitation, rapid decision cycles, and authentic role rotation (manufacturing lead, integration lead, test/QA, controls). The visibility of a working rover created positive spillovers—peer interest, informal knowledge transfer, and potential micro-tasks for the wider class (e.g., print farms, tolerance studies). Resource-wise, a small team

minimised queueing on printers, benches, and test spaces, preserving momentum.

Some of the drawbacks of conducting the pilot project with only a small group include exclusivity – introducing risks of equity concerns and uneven skill exposure across the full class. A single project may not scale to 30 students without fragmenting tasks into sub-assemblies or offering parallel challenges. Assessment comparability also becomes complex when only a subset experiences high-authenticity work. Finally, the small team is sensitive to absences or skill gaps; if one role lags (e.g., controls), the critical path stalls.

“This was where the group ran into big issues with the code... when we inputted a line of code... the error code read ‘file not found’... Each individual ‘file not found’ issue was resolved through ChatGPT... or else solved with the help of Mike and Adrian.”

D. Lessons Learned and Future Improvements

Lessons learned from this pilot implementation of the CBL project include the following points: -

1. Front-loaded DfAM and metrology – Need to formalise a pre-print verification gate (tolerance coupons, critical fit simulations) to reduce delays and reprint cycles for the project.
2. Configuration management – Standardising the BOM variants and keeping parametric CAD/print profiles under version control would also help reduce wasted time and resources; mandating issue templates and pull requests is also good in this regard.
3. Testing culture – where possible, minimal viable tests (MVTs) per phase (e.g., wheel module spin torque, current draw profiles, step-response metrics) should be defined, with logged pass/fail criteria.
4. Scaffolding autonomy - provide starter nodes/scripts for sensor calibration, state estimation, and PID templates; align stretch goals with timeboxes.
5. Scaling strategy for larger cohorts - To broaden participation, running multiple rover streams or modular sub-projects (mobility, perception, UI) with an integration day would allow more students to participate in the project in parallel. Introducing cross-team design reviews if this were the case would allow for shared learning and rubric parity.
6. Assessment refinement – A better balance between product and process needs to be found - adding reflective journals, peer assessment, and artefact quality alongside demo performance might help in this regard. Another option is to include a short viva to probe individual understanding.

Embedding an open-source, mission-inspired robotics platform such as the ExoMy project described here within a CBL framework can deliver deep, transferable learning for mechanical/manufacturing undergraduates. With intentional scaffolds for DfAM, integration, and configuration control—and with a plan to scale access—this model is well-positioned

to enhance engagement, technical competency, and professional skills across larger cohorts.

“We found that the designs were very smooth, with precise tolerances and smooth finishes (as long as we printed each part in the correct orientation).”

“... funding for all parts... as well as use of all the equipment needed... including 3D printers & filament, soldering irons and more.”

“Students demonstrated significant growth in technical capability, especially in areas like additive manufacturing, wiring and integration, and troubleshooting Raspberry Pi compatibility issues. By the end of the project, they were far more confident working independently with unfamiliar tools and technologies.”

While the Challenge-Based Learning (CBL) framework proved highly effective in promoting engagement and multidisciplinary skill development, it also introduced several pedagogical challenges that warrant consideration. The success of the approach relied significantly on student autonomy, requiring sustained self-directed effort outside structured contact hours. This placed varying demands on students depending on prior experience, confidence, and time management capabilities. In addition, the resource-intensive nature of the project—particularly in terms of access to additive manufacturing facilities, hardware components, and technical support—introduced logistical constraints that may impact scalability. Managing these factors requires careful instructional design, including structured checkpoints, clearer scaffolding for independent work, and coordinated resource planning to ensure equitable participation and consistent learning outcomes across cohorts. Future work will explore strategies to mitigate these challenges through enhanced scaffolding, workload balancing, and more flexible access to shared resources.

Furthermore, this pilot project was conducted with a focused cohort of four students. However, it provides a structured framework that can be extended to larger cohorts through modularisation and parallelisation strategies. Future implementations could involve multiple rover development streams or decomposition into subsystem-focused projects (e.g., mobility, sensing, control), enabling broader student participation while maintaining technical depth. The introduction of coordinated integration phases, shared assessment rubrics, and cross-team design reviews would support scalability while preserving alignment in learning outcomes and assessment standards.

V. CONCLUSION & FUTURE WORK

This Challenge-Based Learning (CBL) project demonstrated that an open-source, mission-inspired robotics platform — ESA's ExoMy Mars Rover — can deliver rich, multidisciplinary learning for undergraduate Mechanical and Manufacturing Engineering students. Working as a focused team of four within the REEdI program at MTU, Tralee, students progressed from interpreting technical documentation to 3D printing, assembling, integrating electronics, and programming a functional rover. The project catalysed engagement by combining tangible, iterative making with an inspiring space-exploration narrative, while cultivating core competencies in Design for Additive Manufacturing (DfAM), systems integration, version control, and structured testing.

Key strengths included authenticity and ownership, where the clear end goal and visible progress sustained motivation; multidisciplinary depth, requiring students to connect material choices and tolerances to assembly performance and control behaviour; professional practice development, with agile routines strengthening communication, documentation, and decision-making; and transferability, as skills in additive manufacturing, electromechanics, and Python-based control are directly applicable to Industry 4.0 contexts. Qualitative feedback from students and facilitators indicated high satisfaction and perceived growth in both technical and soft skills

"The servos caused considerable problems... the source code... had to be edited... this was achieved in the end however took considerable time."

"It was clear throughout the project that students were deeply engaged—many voluntarily spent extra hours refining prints, debugging code, and iterating on assemblies. Their enthusiasm remained high even when tasks became challenging."

The project also highlighted some constraints in the pilot implementation. Operating with a small sub-cohort maximised facilitation intensity and resource utilisation but raised questions of scalability and equity within a larger class of 30. Technical bottlenecks clustered around tolerance control, supply substitutions, and control stack calibration, suggesting the need for stronger front-loaded DfAM checks, configuration management, and scaffolded autonomy.

Future iterations of the project will focus on: formal pre-print verification (tolerance coupons, fit simulations); (2) configuration and quality management (parametric CAD control, standardized BOM variants, mandatory issue tracking); (3) testing culture with minimal viable tests per subsystem; (4) scaffolded autonomy via starter calibration nodes, PID templates, and staged sensing; and (5) scaling strategies for larger cohorts—parallel rover streams or modular sub-projects with a coordinated integration event, common rubrics, and peer assessment for parity. These approaches provide a pathway to scale the project to larger

cohorts while maintaining equitable access, structured assessment, and consistent learning outcomes across diverse student groups. Future work will also explore more structured integration of AI-assisted learning tools, including guidelines for responsible and effective use within engineering project workflows. These developments aim to transition the project from a pilot implementation toward a scalable, data-informed educational model.

Future work will also focus on introducing more explicitly defined, measurable evaluation criteria to assess both technical system performance and student learning outcomes in subsequent implementations. These may include metrics such as component reprint frequency, manufacturing cycle times, system integration success rates, and defined performance indicators for rover functionality (e.g., mobility reliability, control responsiveness, and task completion). The incorporation of structured logging and lightweight data capture during project execution will support more systematic analysis of technical progression and student engagement.

From a scalability perspective, future iterations will explore structured strategies for extending the project to larger cohorts while maintaining pedagogical integrity. These include modularising the project into subsystem streams (e.g., mobility, control, sensing), enabling parallel team-based development, and coordinating integration events to ensure system-level coherence. The use of standardised rubrics, shared assessment frameworks, and cross-team design reviews will support consistency and comparability across groups. Additionally, scalable resource management approaches—such as distributed additive manufacturing workflows and shared testing protocols—will be investigated to ensure efficient deployment in larger class settings.

In closing, embedding ExoMy within a CBL framework offers a compelling pathway to deepen engagement, accelerate competency development, and align undergraduate learning with contemporary engineering practice. With targeted scaffolds and a plan to broaden access, the next iteration is poised to deliver even stronger learning outcomes and more equitable participation across the full cohort.

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