ENGINEERING GROUP SUCCESS THROUGH ACTIVE INTERVENTIONS AND COMMUNITY BUILDING

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ABSTRACT
Teamwork is an essential part of engineering projects, and it is well established that diverse teams deliver better outcomes: the open-ended nature of engineering challenges requires a variety of viewpoints to develop creative solutions, which leads to more robust, well-rounded results. However, diversity can also introduce challenges, such as communication barriers and bias, potentially leading to misunderstanding and conflict. This is particularly true in educational settings where the main (perceived) outcome is a grade rather than a real-world engineering solution and where students' prior experiences have often been quite homogeneous, e.g. in single-sex schools. This dynamic can result in minoritised team members feeling their contributions are less highly valued and not being listened to by the team. Educator's responses to this issue range from passive acceptance, i.e. arguing that such experiences prepare students for future workplace realities, to active interventions. Examples of the latter include the mandated rotation of administrative roles, assignment of roles based on self-identified skills and areas for growth and avoiding having a lone minoritised student in a further homogeneous team. These interventions, amongst others, have been incorporated into the Design, Make, Test module at the Mechanical Engineering undergraduate programme at Imperial College London. Arguably the most significant contributor to student wellbeing has been the co-creation, with student representatives, of dedicated active communities that organise informal sessions where students share experiences, realising they are not alone. Therefore, planned future developments include extending this approach to other underrepresented groups in the cohort whilst also raising awareness among majority-group students about any undesired behaviours and encouraging them to adapt their actions.

Keywords: Engineering projects, co-creation, inclusivity and diversity

1 INTRODUCTION
Most engineering degrees comprise one or more modules where a major project is delivered by the students as part of a team. The reasoning behind such modules is well documented: firstly, employees expect engineering graduates to be competent not only in their main technical disciplines but also in transferrable skills including communication, collaboration, project management, problem-solving under uncertainty, and critical self-reflection **Error! Reference source not found.**, **Error! Reference source not found.**. Secondly, it has been long-established that it is not domain-specific knowledge that graduates most regularly draw upon in their daily professional practice, instead, they consistently identify interpersonal skills, engineering reasoning, and the ability to work effectively within a team as the competencies that matter most in early careers **Error! Reference source not found.**, **Error! Reference source not found.**. Thirdly, the Washington accord **Error! Reference source not found.**, which defines a range of attributes of graduates, stipulates that engineering degrees teach and assess students' ability to collaborate in teams. These transferable skills are typically developed as part of a design-focussed project in which students are tasked to collectively deliver an engineering solution within specific constraints. Such design projects require students to mirror the realities of professional engineering practice, i.e. negotiate roles, manage conflict, coordinate effort across individuals with different strengths and weaknesses, and communicate their decisions to a range of stakeholders. A student's experience of delivering their group project has implications for module-level learning and assessment outcomes, as well as for students' broader confidence, sense of belonging, and educational outcomes. In 2023, EngineeringUK **Error! Reference source not found.** reported a significant ethnicity awarding gap in engineering, with 28.1% of Black students receiving a first-class honours degree, compared to an overall average of 44.8% for all students. Yet groups with diverse backgrounds

consistently outperform homogeneous groups of like-minded individuals, even when the like-minded teams are composed of members with higher grades in other modules **Error! Reference source not found.**, **Error! Reference source not found.**. Tian **Error! Reference source not found.** argues that gender balance within a team correlates with stronger performance on novelty and impact, whilst the 4th edition of the UK Engineering Council's Accreditation of Higher Education Programmes explicitly places a strong emphasis on inclusive design as well as equality and diversity as graduate learning outcomes **Error! Reference source not found.**, reflecting a broader acknowledgement that diverse teams deliver better-rounded engineering solutions. Group work has the potential to reduce awarding gaps **Error! Reference source not found.**, although it is well-established that peer assessment can increase it **Error! Reference source not found.**, meaning that careful management and support of diversity in teams is essential for equity. It needs to be noted that the students entering engineering programmes typically have relatively uniform prior educational backgrounds, see e.g. **Error! Reference source not found.**, **Error! Reference source not found.**. In addition, the makeup of the student-body is far from diverse; mechanical engineering as a discipline sits at approximately 20% female participation and engineering in general has a broadly 70% white ethnicity **Error! Reference source not found.** whilst for most degree programmes the number of students with a non-binary or specific disability status is too small to make any statistically relevant statements. The design project may represent a student's first sustained experience of working alongside peers from different backgrounds and with markedly different experiences. This has implications for how students communicate, how they interpret the contributions of their peers, and how well-equipped they are to recognise and respond constructively to the dynamics that diversity can introduce into a team. In this paper, we describe a series of active interventions in a third-year engineering group design module and reflect on their observed impact on the student experience.

2 BACKGROUND AND MOTIVATION

Team diversity does not automatically translate into better outcomes. Assumptions about competences or roles based on demographic characteristics may result in the contributions of minoritised members being systematically undervalued **Error! Reference source not found.**, **Error! Reference source not found.** whilst also reinforcing existing biases. This undermines social integration and may even result in perceived or actual situations of conflict **Error! Reference source not found.**, **Error! Reference source not found.**. Unconscious bias has been shown to negatively affect the contributions and experiences of minoritised team members **Error! Reference source not found.**, **Error! Reference source not found.**. A compounding factor in educational contexts is the effect of demographic isolation within a team: it has been shown that female students in STEM group work express less comfort, show reduced verbal participation, and experience greater anxiety when they are the sole representative of their demographic group **Error! Reference source not found.**, **Error! Reference source not found.**. This so-called token dynamic, in which a minoritised member is numerically isolated within an otherwise homogeneous team, has been shown to increase performance pressure and reduce the likelihood that the individual's contributions will be equitably recognised or acted upon **Error! Reference source not found.**, **Error! Reference source not found.**. Where teams default to a division of labour based on perceived rather than demonstrated competence, minoritised members are frequently assigned peripheral or administrative roles, regardless of their technical ability, with the consequence that they derive less learning value from the experience than their majority-group peers **Error! Reference source not found.**. The cumulative effect is that students who are most exposed to bias within the group project experience are also those most likely to disengage from engineering as a discipline. For example, female students in engineering have reported that male peers gave their ideas less credit and excluded them from technical work in group projects **Error! Reference source not found.**, a dynamic that both affects individual wellbeing and creates structurally unequal learning opportunities within the team. The Design, Make, Test (DMT) module is a compulsory third-year module taken by the entire cohort of approximately 180 undergraduate students in Mechanical Engineering at Imperial College London. With a time commitment of 500 hours per student, the module serves as the capstone project for the engineering design-focused learning within the degree, building on individual and small-group design work undertaken in the first and second years. The formal learning outcomes span the full engineering design cycle, from the derivation of customer requirements through manufacture, testing, and project management, with the explicit aim of exposing students to a realistic project structure **Error! Reference source not found.**. The module is organised around a so-called

superproject format, with a superproject comprising three teams of four students that collaborate to deliver a functioning prototype as part of a larger, integrated engineering system. Across the cohort, fifteen distinct super projects are defined each year, each with a unique technical brief ranging from a rocket engine to the propulsion system of a robotic turtle. Compared to traditional small-group projects, this nested structure enhances the authenticity of the educational design project experience, allowing more complex problems to be tackled whilst requiring students to develop the communication, collaboration, and interpersonal skills that characterise real-world engineering practice. Each subassembly team is supported by a dedicated supervisor acting as a technical specialist, whilst an overarching project director takes the role of client and coordinates integration across the three subassemblies. A systems engineering team, comprising representatives from each subassembly, meets fortnightly with the project director to maintain alignment with the overall project brief and to manage interfaces between the three subassemblies. Further pastoral and professional support are provided by a team comprising the module leader, a senior Teaching Fellow being responsible for student wellbeing, the Departmental wellbeing advisor, and EDI coordinator, who offer confidential guidance to students throughout the project without involvement in assessment **Error! Reference source not found.**. Staff to provide this supervision and support structure amounts to approximately 2 full-time equivalents on an annual basis, and includes academics, teaching fellows, laboratory and workshop technicians as well as administrative staff. Evidence for the significance of diversity and inclusion dynamics in group design projects were found in the feedback received through the National Student Survey (NSS) over the period 2022-2025. Analysis of open-text responses across this period identified a consistent pattern: whilst feedback on personal projects and general module experiences was predominantly positive, negative comments associated with group design projects related specifically to diversity and inclusion. Students described experiences in which disability within a team was not supported amongst other group members and called for greater EDI awareness and training among staff, as well as highlighting a desire for more structured attention to diversity within the group project experience. This pattern was consistent over multiple years, suggesting that EDI (equality, diversity and inclusion) related difficulties in group work are a persistent feature of the student experience. The reported negative consequences of teamwork risk undermining the wide range of positive outcomes that working in a team of peers is actually intended to support and provide a clear evidence base for the need for intervention.

3 INTERVENTIONS

In response to the notion that student experience in group design projects can be improved through addressing diversity and inclusion dynamics, a series of active interventions and informal support have been incorporated into the DMT module. These interventions operate at three levels: the composition of teams, the structure of roles and responsibilities within them, and support with team structures.

3.1 Team composition

At the level of team composition, care is taken to avoid placing a single marginalised student within an otherwise homogeneous group. As a trial, this has been introduced for gender: gender-based isolation within a team significantly increases the pressure on the female team member and reduces the likelihood that their contributions will be equitably valued **Error! Reference source not found.**, **Error! Reference source not found.**. By ensuring that female students are not alone in their team of four students, the intervention seeks to create a team environment in which female students are less exposed to the performance pressures and marginalisation associated with token status. Structuring teams to prevent this dynamic may be seen as a reasonable protective measure within an educational context. However, it raises a legitimate pedagogical concern: in most professional engineering environments, female engineers cannot rely on such structural protection, and a female student who has only ever worked in carefully balanced educational settings may be poorly equipped for the realities of workplace culture. This tension is not easily resolved and arguably should not be resolved by simply accepting isolation as a necessary hardship on the grounds that it reflects industry norms. Accepting that exposure to marginalisation constitutes preparation for it implicitly places the burden of adaptation on minoritised students rather than on the wider team and institutional culture. To our knowledge, there is no evidence that students having experience being a minority in a project develop greater professional resilience as a result. In contrast, Hu **Error! Reference source not found.** and Isaac **Error! Reference source not found.**, argue that such experiences increase the likelihood of disengagement and attrition.

3.2 Team roles

Within teams, two complementary approaches to role assignment have been introduced. The first is a mandated rotation of administrative roles such as chairing meetings, keeping meeting minutes and maintaining project documentation. This ensures that no single team member, by default or by informal consensus, is expected to fill this position for the duration of the project. Whilst some people may see these roles as essential and highly influential in any team process, in most educational settings they are seen as a tedious, administrative burden that may be assigned to a noncomplaining team member. Guiding meetings, keeping minutes and documenting are, however, essential transferrable skills for any engineer. The second approach to role assignment is a skills-based assignment process, in which students self-identify their areas of strength and areas in which they wish to develop, with roles allocated accordingly. This approach serves a dual purpose: it identifies, values and draws upon the diversity of skills and perspectives within the team more deliberately, and it provides a structured basis for role allocation that is grounded in individual agency rather than unexamined assumptions about competence. It is, however, in direct conflict with the general desire to work efficiently and aim for the highest possible mark in the minimum amount of time. At present, the self-identified skills-based assessment is implemented through a non-regulated informal process during the initial stages of the project, with the outcomes reported as part of in the groups project plan. A more formalised assessment, e.g. performed whilst the supervisor is in attendance, could be considered to ensure the process gets appropriate consideration and attention whilst all students can contribute equally.

3.3 External Support

Informal networking sessions for marginalised students are run once or twice per term. Similarly to the approach piloted for team formation, this initiative was first trialled for gender, with students who identify as women, or nonbinary, being invited to participate. Sessions are hosted by the module leader and supported by the Head of Student Experience and the Department's EDI Coordinator and are scheduled outside of regular lecture hours - food is provided. The core format is a lightly facilitated discussion centred on the student experience: this normalises the difficulties and challenges certain students are facing, lowering the barrier to addressing them whilst providing an opportunity for both staff and peers to share advice and strategies for addressing those challenges. The sessions also function as a feedback mechanism, giving staff direct insight into the minoritised student experience.

4 OUTCOMES, DISCUSSION AND CONCLUSION

The design of the module has been amended over several iterations to address EDI related issues. This development has taken place using a co-creation approach with students and has resulted in a self-sustaining feedback and co-creation cycle via the generation of the informal community support sessions. Attendance at these sessions has grown year on year, with increasingly tangible outcomes, such as newly introduced questions assessing group dynamics that have been incorporated into the peer assessment exercise. Student feedback gathered during these sessions, as well as in student experience focus groups and the Departmental EDI survey evidences a change in culture within the undergraduate cohort where our marginalised students are happier in their group work and more confident in raising concerns on their projects, enabling faster resolution. In that sense, feedback received from specific focus groups e.g. on gender is used help to make the experience more inclusive for all students. On team composition specifically, a typical response from a student in the National Student Survey (NSS) directly attributed to the DMT module is: "*I don't know how I would cope without [being put in pairs].*" On team roles, the number of complaints from students about being "*stuck in an admin role*" have decreased noticeably. From these experiences and from literature it is clear that team composition strategies in educational settings serve a developmental purpose that is distinct from professional practice. By ensuring that minoritised students are able to participate equitably during the period in which core engineering competencies and professional identities are being formed, interventions seek to establish a foundation of confidence and experience from which students are better placed to navigate less equitable environments in their subsequent careers. The goal is not to shield students from difficulty indefinitely, but to avoid allowing structural disadvantage to interfere with the formation of the very capabilities they will need when that protection is no longer available, or to impact their academic outcomes. As such, future steps to be taken will include considering other marginalised groups as part of team composition, using a community-led approach, whilst taking care to not further marginalise groups or make anyone feel othered. One notable example is a study into the student experience in

collaborative projects led by two East Asian students, following a pilot elsewhere in the University. Whilst the project has aimed to take an asset-based approach through co-creation, empowerment and structural change, limitations still exist, predominantly in the form of majority-group behaviours. Some measures have been put in place to address these through whole cohort awareness and skill training sessions throughout the curriculum, such as Allyship, Unconscious Bias and Active Bystander as well as Professional EDI skills and inclusive teamworking. However, these sessions are not always well-attended, and their learnings not always implemented, so further work is needed. In the longer-term, awareness-raising activities will have to be introduced within the module, aimed at majority-group students, with the objective of encouraging reflection on team behaviours and dynamics that may, often inadvertently, disadvantage minoritised members. This initiative aims to foster a cohort of graduates with inclusive teamworking skills and recognise that structural change is required when addressing the interpersonal behaviours that undermine inclusion.

REFERENCES

[1] Souppez J. B. Engineering Employability Skills: Students, Academics, and Industry Professionals' Perception. *Journal of Engineering Education*, 53(1), 135-143, (2025).

[2] Kimpton C. and Maynard N. Factors shaping teamwork skills development in tertiary engineering education: A systematic literature review. *European Journal of Engineering Education*, 50(2), 253-280, (2025).

[3] Wolfe L. Understanding the Careers of the Alumni of the MIT Mechanical Engineering Department, BSc thesis, Massachusetts Institute of Technology, (2004).

[4] Bravo E., Bayram D., van der Veen J. T. and Reymen I. Students' Learning Gains in Extracurricular Challenge-Based Learning Teams. *European Journal of Engineering Education,* 2024, 1-18, (2024).

[5] International Engineering Alliance. The Washington Accord, (2026). https://www.internationalengineeringalliance.org/accords/washington-accord.

[6] UKEngineering. Engineering in higher education (2023), available at: https://www.engineeringuk.com/media/mxxjczpv/engineering-in-higher-education_report_engineeringuk_march-23.pdf.

[7] Page S. E. The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools, and Societies. Princeton: Princeton University Press; 2007.

[8] Isaac S., Tormey R. and Cross K. J. Educating engineering students to address bias and discrimination within their project teams. *Science and Engineering Ethics* 29(1):5, (2023).

[9] Tian T. Y., Ippolito M. R. and Uzzi B. Gender-diverse teams produce more novel and higher-impact scientific ideas. *Proceedings of the National Academy of Sciences* 119(36), e2200841119, (2022).

[10] Canal M. M. and Child R. Impact of the type of assessment on awarding gaps in bioscience undergraduate degrees. *Assessment & Evaluation in Higher Education* 50(6), 982-995, (2025).

[11] Engineering Council. The Accreditation of Higher Education Programmes (AHEP), 4th ed. London: Engineering Council, (2020). Available at https://www.engc.org.uk/resources-and-guidance/education-and-skills/higher-education-programmes.

[12] Matthews J. and Croft T Widening participation and the mathematics problem in engineering education. *International Journal of Mathematical Education in Science and Technology*, 51(7), 1045–1063, (2020).

[13] Smith E. and White P. Subject choice, attainment and progression into STEM degrees in England. *British Educational Research Journal*, 47(4), 1021–1043, (2021).

[14] Hu S., Wolfe J., Klebanov L., Clark R., Ceylan E. and Borchert O. The influences of student- and school-level factors on engineering undergraduate student success outcomes: a multi-level multi-school study. *International Journal of STEM Education* 9(1):14, (2022).

[15] Eddington S. M., Meyers K. L. and Ohland M. W. Building inclusion in engineering teaming practices. *Studies in Engineering Education* 4(1), 1-22, (2023).

[16] Horwitz S. K. and Horwitz I. B. The effects of team diversity on team outcomes: a meta-analytic review of team demography. *Journal of Management* 33(6):987-1015, (2007).

[17] Theobald E. J., Eddy S. L., Grunspan D. Z., Wiggins B. L. and Crowe A. J. Student perception of group dynamics predicts individual performance: comfort and equity matter. *PLOS ONE.* 2017;12(7):e0181336.

[18] Masen M. A., Silversides R., Guyott C., Mohammed I. K. and Agg C. Superprojects and superpowers: how teams within teams can enhance students interpersonal and engineering skill development. In: Bohemia et al, *Proceedings of the International Conference on Engineering and Product Design Education*, Malta, September 2025.
[19] Almasri F., Hewapathirana G. I., Ghaddar F., Lee N. and Ibrahim B. Demographic isolation and attitudes toward group work in student-selected lab groups. *PLOS ONE*. 2024;19(9):e0310918.
[20] Heilman M. E. and Haynes M. C. No credit where credit is due: Attributional rationalisation of women's success in male–female teams. *Journal of Applied Psychology* 90(5), 905-916, (2005).
[21] Sekaquaptewa D. and Thompson M. Solo status, stereotype threat, and performance expectancies: Their effects on women's performance. *Journal of Experimental Social Psychology* 39(1), 68-74, (2003).