# Engineering Identity Development Among International Students in UK Foundation Year

**Dr. Madeline Polmear, King's College London**

Madeline Polmear is a lecturer (assistant professor) in engineering education at King's College London. Her research interests relate to engineering ethics education and the development of societal responsibility and professional competence through formal and informal learning. Madeline received her Bachelor's in environmental engineering, Master's in civil engineering, and PhD in civil engineering at the University of Colorado Boulder, USA. Prior to joining KCL, she was a Marie Sklodowska-Curie, EUTOPIA Science & Innovation Cofund Fellow at the Vrije Universiteit Brussel, Belgium.

# Engineering Identity Development Among International Students in UK Foundation Year


## Abstract

This work in progress paper details the creation of a new module (course) that was designed to foster macroethical and affective development and support students' engineering identity development. The module is part of a Foundation year for international students wanting to progress into a bachelor's degree in the UK. The creation of a new required module for engineering students presented the opportunity to imagine a year-long introduction to what engineering is and what it means to be an engineer. The module integrates the Inner Development Goals (IDG), which is a framework of skills and qualities needed to address the UN Sustainable Development Goals (SDG). The IDG were developed from a perspective that technical knowledge is not the limiting factor in addressing the climate crisis and related societal challenges, but rather, it is the emotional and cognitive skills of individuals and organizations to fulfil the vision of the SDG. Learning activities throughout the year were designed to support students' engineering identity, including the trajectory of their conceptualization and the role, if any, that affective and macroethical considerations play. This work aligns with the LEES conference theme pertaining to personal experiences with integrating liberal arts and engineering to overcome the artificial boundary between social and technical. Although the need for sociotechnical integration and frameworks for related skills are established in the LEES community, IDG provides a novel conceptualization, link to sustainability and other macroethical responsibilities, and affective component that can contribute to a holistic understanding of what is means to be an engineer.


## Introduction and Background

This section is organized to briefly synthesize relevant literature related to engineering identity development, macroethics in engineering education, and the experiences of international students in the UK. Throughout the paper, the term 'module' is used, which is equivalent to a course in the US context.

### Engineering Identity Development

Engineering identity development has been a growing area of research over the past few decades through both empirical work and systematic reviews. Part of the interest in identity development stems from its interconnection with pervasive challenges in engineering, such as motivation [1], recruitment and retention [2], and gendered and racialized marginalization [3]. This rise in qualitative and quantitative work exploring identity indicates the many ways in which it is defined. Although identity has been understood as "who are you?" [4], it is a complex and multi-faceted construct that is defined in the context of engineering as seeing oneself as an engineer [2]. This concise conceptualization then raises the questions of what is an engineer, and how does someone become an engineer? There are different perspectives for addressing such questions, which Huff and Ross [4] synthesize as personal (how individuals construct their identity to answer who I am as an engineer), social (how do social contexts define identities of individuals that shape how they define themselves as engineers), and sociocultural (how does the sociocultural context shape how we define ourselves as engineers).

An understanding of engineering identity amongst university students is thus closely linked to the identity of engineering. Research in the latter has shown the technicist and masculine identity of engineering [5] and the interlocking of masculinity and competition in engineering culture [6]. A review of engineering identity synthesized common aspects that define engineering as problem solving and knowledge in math and science [7] reflecting the technical focus. In light of these dominant narratives, there is ongoing work to disrupt the technicist identity and exclusionary culture of engineering to better reflect the multifaceted roles of engineers and the diverse populations they serve (see, for example, [8]). One framing to broaden the scope of what it means to be an engineer and do engineering is macroethics, the collective societal responsibility of engineers [9].

## Macroethics

Relative to other subjects, ethics has a shorter history in the engineering curriculum with formal inclusion starting in the early 2000s due in large part to accreditation (such ABET and Washington Accord). In the UK, the Engineering Council establishes the Accreditation of Higher Education Programmes (AHEP) [10]. The learning outcomes, which were updated in 2020, include "consideration of applicable health & safety, diversity, inclusion, cultural, societal, environmental and commercial matters" in design (outcome B5), "evaluate the environmental and societal impact of solutions" (B7), "identity and analyse ethical concerns and make reasoned ethical choices" (B8), and "recognize the responsibilities, benefits and importance of supporting equality, diversity and inclusion" (B11) [10]. These outcomes span microethics, the duties of individual engineers within their workplace, and macroethics, the broader responsibilities of engineers to society and the environment [9]. Macroethics provide a framework for broadening engineering ethics from the individualist to collective [11]. In the present study, macroethics are operationalized as the societal and collective responsibilities of engineers that include issues such as sustainability and community impact. This linking of personal, professional, and societal responsibility has gained momentum in recent years [12][13][14] and can help shift the identity of engineers through a more holistic understanding of their role. Engineering ethics education plays a key role in communicating and enculturating the responsibilities of future engineers through their undergraduate studies.

## International Students in the UK

The module detailed in this paper is offered through a Foundation programme that is exclusively for international students; thus, the following review briefly introduces the context of international students in the UK. The UK is the third most popular destination for international undergraduate students behind the US and Australia [15]. In 2021/22, there were 679,970 students from overseas studying at UK universities, which represented one quarter of the student population [15]. The student population represents many countries and diverse cultures. After Brexit, there was 40% decline in students from the EU while the number of students from China, India, and Nigeria has increased in recent years [15]. International students contribute academically, socially, culturally, and economically to UK universities, and their growing numbers have magnified the need to understand their experiences in UK higher education. Challenges such as English proficiency, financial stress, culture shock, and academic environment have been reported among international students [16]. When international students develop their engineering identity, it is one part of a multi-faceted story

in which they are also developing their understanding of self in a different culture and context.

**Research Aims**

The aim of this paper is to present ongoing work on the module design and planned data collection in the context of international undergraduate students' macroethical and engineering identity development. The IDG, discussed in more detail in the following section, provides a novel framework for the social and affective skills necessary for engineers to fulfil their macroethical responsibilities and define a more holistic identity of engineering.

**Theoretical Framework**

The module design was guided by the Inner Development Goals (IDG) [17]: a framework of skills and qualities needed to address the UN Sustainable Development Goals (SDG). The IDG were developed from a perspective that technical knowledge is not the limiting factor in addressing the climate crisis and related societal challenges, but rather, it is the emotional and cognitive skills of individuals and organizations. Therefore, to fulfil the vision of the SDG, we must turn our attention to skills and qualities that people need to address complex societal challenges.

This framework was selected because it provides a way to integrate engineering identity and macroethics. What it means to be an engineer is having the skills and attitudes that enable you to address complex, socially relevant issues. From the perspective of the IDG, being an engineer goes beyond acquiring technical knowledge or using math and science to solve issues, it means caring for others and the world, collaborating with others, and acting to enable change. These principles align with macroethics as the responsibilities that engineers have to society and the environment [9].

There are five goals: being (relationship to self), thinking (cognitive skills), relating (caring for others and the world), collaborating (social skills), and acting (driving change). The goals, their related components, and module activities that align with them are presented in Table 1.

*Table 1: Inner Development Goals and their components with related module activities*

| Goal | Components | Module Activities |
|---|---|---|
| Being: relationship to self | • Inner compass<br>• Integrity and authenticity<br>• Openness and learning mindset<br>• Self-awareness<br>• Presence | • Reflective writing |
| Thinking: cognitive skills | • Critical thinking<br>• Complexity awareness<br>• Perspective skills<br>• Sense making | • Introduction to wicked problems |

| | | |
|---|---|---|
| | • Long term orientation and visioning | |
| Relating: caring for others and the world | • Appreciation<br>• Connectedness<br>• Humility<br>• Empathy and compassion | • Design Thinking [25]<br>• Empathic communication activities |
| Collaborating: social skills | • Communication skills<br>• Co-creation skills<br>• Inclusive mindset and intercultural competence<br>• Trust<br>• Mobilisation skills | • Design project in group<br>• Labs with partner<br>• Seminar activities in groups<br>• Inclusive design, bias in design |
| Acting: enabling change | • Courage<br>• Creativity<br>• Optimism<br>• Perseverance | • Open-ended design challenge in seminar<br>• Open-ended soft prototype challenge |

There are many conceptualizations of the skills and attributes that engineers need, from accreditation learning outcomes [18][10], empirical frameworks of generic skills [19], to literature-based frameworks of competencies specific to sustainability [20]. Components of the IDG, such as critical thinking and communication skills, are common amongst such frameworks. The unique contribution of IDG is the integration of cultivating relationship with self, care for others, and change.

**Context**

This section details the context of the module, which might be less familiar to a US audience. Foundation programs offer one year of study prior to undergraduate to help students prepare for their bachelor's course. There are 105 English higher education institutions that offer a foundation year, 23 of which are based in London [21]. Programs at different universities can be tailored to a variety of subjects and student demographics and often have the aim of broadening participation. The foundation year offers another pathway into higher education, particularly for students from underrepresented backgrounds and adult learners who are returning to formal education [21]. In 2021/22, there were 69,325 foundation year entrants in England, which is up from 8,470 entrants 10 years prior [21]. This growth represents an annual increase of 20%, which far outpaces enrolment changes for first year undergraduate students. For example, from 2020/21 to 2021/22 there was a 29% increase in student enrolment in the foundation year and a 2% decrease for students in their first-year undergraduate [21]. The data indicate the growing importance of the foundation year as a pathway into higher education for students wanting to study in the UK.

At King's College London, where this work is situated, the foundation program is exclusively for international students who can enter different 'pathways' as areas of focus that will prepare them for entry into a bachelor's degree in that discipline. The program offered an

engineering module for the first time in 2023/24. Students on the engineering pathway take three modules with other STEM students (mathematics for natural sciences, English for academic purposes, science and society) and the engineering option module (introduction to engineering). The engineering cohort had 33 students with the highest representation from the Middle East (such as Saudi Arabia, UAE, Lebanon) and China with few from South American countries. The students were 52% female.

The module structure contained lecture once per week (one hour in term one and two hours in term two) and two-hour seminar (three repeated sessions per week for small group teaching). Students also had four labs and one design project that included eight hours in the maker space. The mix between theory and application was intended to address any areas students might not have developed in their previous studies and develop the skills they will need for a bachelor's program.

**Positionality**

As the author and module leader, my identity and background influence both my teaching and research. In particular, being new to teaching, to the university, and to the UK shaped my experience and approach. I started this position in August 2023 and the module began in September. This is my first permanent academic role: immediately prior I completed a postdoc research fellowship in Belgium and before then worked as a postdoc research associate in the US. I moved to London days before the position started with limited first-hand knowledge of higher education in the UK. As a result, I had a steep learning curve in terms of developing a new module in a system that I quickly realized was different from my past experience. I was also given significant freedom in terms of designing the module; the main directive was to focus on physics in term one since students may not have taken physics in high school and cover engineering science and design in term two. My approach to designing the module, particularly in the second term, was informed by my core research area of engineering ethics education. I am personally and empirically oriented toward a macroethical view of engineering, and my years of studying other educators' challenges and experiences in engineering ethics education motivated me to provide opportunities for students to learn about the societal impact of engineering throughout the year.

My initial exposure to the IDG was through an external secondment during my postdoc fellowship. I worked with an urban sustainability company in Belgium, and the CEO shared the IDG as a framework that guided the work and decision-making of the company. I was drawn to the IDG since it provided a natural integration of my research interests and teaching aims. This first year of the module provides an opportunity to pilot the IDG as a guiding framework for teaching.

**Research Methods**

This section introduces the planned data collection methods. The module is ongoing at the time of writing, so data collection will primarily take place at the end of the academic year.

<u>Draw an Engineer</u>

During the first and last class of the module, students have completed/will complete a written reflection on what engineering is, what engineers do, and a drawing of an engineer. This activity is based on the Draw-a-Scientist Test (DAST) [22]. The DAST was developed to

understand the age at which children represent the stereotypical or standard image of a scientist when asked to draw one. The standard image of a scientist includes lab coat, eyeglasses, facial hair, symbols of research, symbols of knowledge, and technology. Chamber's study found by second grade such stereotypes crop up and increasingly so with older children: by fifth grade, the majority of students had 3-4 of the indicators in their drawings. The research indicates stereotypical conceptions of scientists that begin at a young age.

The test has been modified for engineering with the Draw an Engineer Test (DAET), which has been used with elementary through high school students [23]. The test includes the following questions:

- In your own words, what is engineering?
- What does an engineer do?
- Draw a picture of an engineer at work?
- Do you know any engineers?
- If so, who are they?

The activity was distributed to all students on the first day of lecture to understand their baseline conceptions of engineering. I recognize these images and responses are informed by a range of factors such as previous exposure to engineering through work or family, public discourse around engineering, and fictional or real engineers in the media. The visual and written responses provide insight into how the students view the identity of engineers, which at this point, they may or may not see themselves as part. The activity will be given again during the last class to analyse any changes after studying engineering for one year and being exposed to the IDG framework through various learning activities.

Narrative Interview

Narrative interviews with journey mapping will be conducted with a sub-set of students at the end of the academic year. Journey mapping provides a structured approach for participants to reflect on important experiences, interactions, and individuals in their lives and produces a visual representation. This approach has been used to explore engineering students' identity development [24]. Young and colleagues [24] shared the methodology for exploring identity development for engineering students at one university in Australia, and I plan to adopt a similar process.

Student Written Reflection

An additional source of evidence for understanding students' engagement with IDG and development in their understanding of engineering is written reflection. There are reflection components in two of the four summative module assessments and one formative assessment. For their formative lab report (on building and analysing circuits), summative lab report (on exploring lift and drag forces with a wind tunnel), and individual design report (on designing and manufacturing a miniature wind turbine), students must include a section describing the skills they developed as a result of the activity, any challenges they encountered, and their approach for overcoming the challenges.

## Future Work

Future work will focus on data collection and analysis across the Draw an Engineer Test, journey mapping interview, and student written reflection. Synthesis across these sources of information will generate insights to inform research and practice. Since the present paper is work-in-progress, it is intended to introduce the module context, guiding framework, and research approach with the data analysis and findings included in future publications.

Given the students all come from outside the UK and are navigating their transition to a new country, to university, and new culture, I am interested in how all these factors play into their identity development. The analysis will thus take a social approach [4] to understand how students come to understand themselves as engineers in this context. As an example, interactions with students have indicated the importance of considering the intersection of gender and engineering identity. One woman in the cohort spoke to me during the transition week about how excited and surprised she was that I (also a woman) was teaching engineering since there are not many women in engineering. A group of women had a similar conversation with me after the first lecture, and one excitedly shared that she drew me for the DAET. Other students have spoken to me about how a Saudi oil company is paying for their study in the UK with the expectation that they will return to work for the company afterward. Understanding this part of the students' journey can indicate how aspects of their identity might be in tension with the understanding of engineering that underpins the module. Future work will further explore such factors within the complex tapestry of students' engineering identity development.

## Conclusion

This work in progress paper details the design of a new module that aims to foster macroethical and affective development within the constraints of a technical introduction to engineering. The course is part of a Foundation year for international students wanting to progress into a bachelor's degree in the UK. The creation of a new required module for engineering students presented the opportunity to imagine a year-long introduction to what engineering is and what it means to be an engineer. The course integrates the Inner Development Goals (IDG), which is a framework of skills and qualities needed to address the UN Sustainable Development Goals (SDG). This framework was selected because it provides a way to integrate engineering identity and macroethics: what it means to be an engineer is having the skills and attitudes that enable you to address complex, socially relevant issues. Future work will explore students' engagement in the IGD and the role, if any, it has on their engineering identity development.

## Acknowledgements

This worked is supported by the Department of Engineering and King's International Foundation at King's College London. The views expressed are my own.

## References

[1] A. Godwin and A. Kirn, "Identity-based motivation: Connections between first-year students' engineering role identities and future-time perspectives," *Journal of Engineering Education*, vol. 109, no. 3, pp. 362–383, 2020, doi: 10.1002/jee.20324.

[2] A. Patrick and M. Borrego, "A Review of the Literature Relevant to Engineering Identity," in *2016 ASEE Annual Conference & Exposition Proceedings*, New Orleans, Louisiana: ASEE Conferences, Jun. 2016, p. 26428. doi: 10.18260/p.26428.

[3] M. S. Ross, J. L. Huff, and A. Godwin, “Resilient engineering identity development critical to prolonged engagement of Black women in engineering,” *Journal of Engineering Education*, vol. 110, no. 1, pp. 92–113, 2021, doi: 10.1002/jee.20374.
[4] J. Huff and M. Ross, “Advancing an Integrative Perspective of Identity in Engineering Education,” in *International Handbook of Engineering Education Research*, A. Johri, Ed., New York: Routledge, 2023. doi: 10.4324/9781003287483.
[5] W. Faulkner, “`Nuts and Bolts and People’: Gender-Troubled Engineering Identities,” *Soc Stud Sci*, vol. 37, no. 3, pp. 331–356, Jun. 2007, doi: 10.1177/0306312706072175.
[6] S. Secules, “Making the Familiar Strange: An Ethnographic Scholarship of Integration Contextualizing Engineering Educational Culture as Masculine and Competitive,” *Engineering Studies*, Sep. 2019, Accessed: Feb. 07, 2024. [Online]. Available: https://www.tandfonline.com/doi/full/10.1080/19378629.2019.1663200
[7] J. Morelock, “A systematic literature review of engineering identity: definitions, factors, and interventions affecting development, and means of measurement,” *European Journal of Engineering Education*, vol. 42, pp. 1–23, Feb. 2017, doi: 10.1080/03043797.2017.1287664.
[8] J. Rohde *et al.*, “Anyone, but not Everyone: Undergraduate Engineering Students’ Claims of Who Can Do Engineering,” *Engineering Studies*, May 2020, Accessed: Feb. 07, 2024. [Online]. Available: https://www.tandfonline.com/doi/full/10.1080/19378629.2020.1795181
[9] J. R. Herkert, “Ways of thinking about and teaching ethical problem solving: Microethics and macroethics in engineering,” *SCI ENG ETHICS*, vol. 11, no. 3, pp. 373–385, Sep. 2005, doi: 10.1007/s11948-005-0006-3.
[10] Engineering Council, “The Accreditation of Higher Education Programmes (AHEP),” Aug. 2020. [Online]. Available: https://www.engc.org.uk/media/3410/ahep-fourth-edition.pdf
[11] E. Conlon and H. Zandvoort, “Broadening Ethics Teaching in Engineering: Beyond the Individualistic Approach,” *Sci Eng Ethics*, vol. 17, no. 2, pp. 217–232, Jun. 2011, doi: 10.1007/s11948-010-9205-7.
[12] A. McAninch, “Go Big or Go Home? A New Case for Integrating Micro-ethics and Macro-ethics in Engineering Ethics Education,” *Sci Eng Ethics*, vol. 29, no. 3, p. 20, May 2023, doi: 10.1007/s11948-023-00441-5.
[13] D. S. Schiff, E. Logevall, J. Borenstein, W. Newstetter, C. Potts, and E. Zegura, “Linking personal and professional social responsibility development to microethics and macroethics: Observations from early undergraduate education,” *Journal of Engineering Education*, vol. 110, no. 1, pp. 70–91, 2021, doi: https://doi.org/10.1002/jee.20371.
[14] M. Polmear, A. R. Bielefeldt, D. Knight, N. Canney, and C. Swan, “Analysis of macroethics teaching practices and perceptions in engineering: a cultural comparison,” *European Journal of Engineering Education*, vol. 44, no. 6, pp. 866–881, Nov. 2019, doi: 10.1080/03043797.2019.1593323.
[15] P. Bolton, J. Lewis, and M. Gower, “International students in UK higher education,” House of Commons Library, Number CBP 7976, Nov. 2023.
[16] N. T. Ramachandran, “Enhancing international students’ experiences: An imperative agenda for universities in the UK,” *Jnl of Research in Internatl Education*, vol. 10, no. 2, pp. 201–220, Aug. 2011, doi: 10.1177/1475240911413204.
[17] Inner Development Goals, “Inner Development Goals: Background, method and the IDG framework,” 2021. [Online]. Available: https://static1.squarespace.com/static/600d80b3387b98582a60354a/t/61aa2f96dfd3fb39c4fc4283/1638543258249/211201_IDG_Report_Full.pdf

[18] ABET, “Criteria for Accrediting Engineering Programs, 2019 – 2020 | ABET.” Accessed: Jan. 15, 2021. [Online]. Available: https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2019-2020/
[19] C. K. Y. Chan, Y. Zhao, and L. Y. Y. Luk, “A Validated and Reliable Instrument Investigating Engineering Students’ Perceptions of Competency in Generic Skills,” *Journal of Engineering Education*, vol. 106, no. 2, pp. 299–325, 2017, doi: 10.1002/jee.20165.
[20] A. Wiek, L. Withycombe, and C. L. Redman, “Key competencies in sustainability: a reference framework for academic program development,” *Sustain Sci*, vol. 6, no. 2, pp. 203–218, Jul. 2011, doi: 10.1007/s11625-011-0132-6.
[21] UK Department for Education, “Foundation year participation, provision and outcomes at HE providers,” Oct. 2023. [Online]. Available: https://explore-education-statistics.service.gov.uk/find-statistics/foundation-years-statistics
[22] D. Chambers, “Stereotypic images of the scientist: The Draw-A-Scientist Test. Science Education, 67(2), 255-265,” *Science Education*, vol. 67, pp. 255–265, Apr. 1983, doi: 10.1002/sce.3730670213.
[23] M. Knight and C. Cunningham, “Draw an Engineer Test (DAET): Development of a Tool to Investigate Students’ Ideas about Engineers and Engineering”.
[24] A. Young, L. Dawes, and B. Senadji, “Using journey maps as a holistic, reflective approach to capture student engineering identity experiences,” *European Journal of Engineering Education*, vol. 49, no. 1, pp. 22–44, Jan. 2024, doi: 10.1080/03043797.2023.2268023.
[25] Stanford d.school, “An Introduction to Design Thinking PROCESS GUIDE.” [Online]. Available: https://web.stanford.edu/~mshanks/MichaelShanks/files/509554.pdf