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Author	Masood, Maryam;Schrock, Lauren;lqbal, Asima
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Embedding Sustainability in Engineering Education Through a Multi-disciplinary Postgraduate Research Methods Module

M. Masood, L. Schrock, and A. Iqbal

WMG, University of Warwick, United Kingdom

m.masood.4@warwick.ac.uk

Abstract

A key strategic aim of higher education is to equip students with the knowledge and skills to address global challenges effectively by embedding sustainability in the curriculum. To achieve this aim, this paper presents a case study on the continuous innovations to embed sustainability within a multi-disciplinary postgraduate research methods module from the 2022/23 academic year to 2023/24. This module is delivered to full-time postgraduate students on six distinct courses, ranging from engineering to business disciplines. In 22/23, sustainability was strategically introduced as a contextual framework to enhance engagement and relatability in the design of the module, which is delivered to postgraduate students to develop essential research competencies and transferable skills. As a result, a phased approach was formulated to embed sustainability in teaching, learning, and assessment: first, to increase students' awareness of the role of sustainability in their respective discipline and expose them to prevailing research trends. Sustainability-related examples and case studies were incorporated across the module content relevant to the multiple disciplines. Second, to provide students an opportunity to investigate sustainability and develop relevant sustainability competencies. In the following academic year (23/24), another assessment was developed that required students to conduct a literature review and create research proposals addressing real-world sustainability issues, necessitating the application of research methodologies within an interdisciplinary and sustainability-focused context. The development of a research proposal relevant to sustainability challenges encouraged students to apply their critical thinking skills in development of research, apply scenario-planning to anticipate future implications of their work (anticipatory competence), and critically reflect on the ethical dimensions of their research (normative competence), aligning the module learning outcomes to UNESCO's sustainability competencies (UNESCO, 2017). This integration was further supported by innovative pedagogical strategies, including problem-based learning and reflective practices, which deepened students' understanding of research methodologies while fostering connections to sustainability goals.

To evaluate the success of this practice, informal feedback from educators affirmed the efficacy of this approach, highlighting the balance achieved between content relevance and workload management. The paper provides the details on the phased approach and a discussion on the challenges and successes of embedding sustainability within research education, offering actionable insights for educators seeking to integrate sustainability competencies into engineering curricula. This case study serves as a model for developing sustainability-oriented engineering education aligned with global development needs.

1 Introduction

Higher education institutions are responsible for preparing students to be changemakers for the future by equipping them with the competencies to engage with complex, real-world challenges. According to Advance HE and the Quality Assurance Agency (QAA, 2021), a key strategic objective of higher education is to equip graduates with the knowledge and skills necessary to contribute meaningfully to sustainable development. This objective aligns with the global urgency to address issues such as climate change, social equity, and responsible innovation, all of which require interdisciplinary thinking and ethical awareness. Hence teaching and learning about research methods at postgraduate level is crucial to developing rigorous analytical and problem-solving skills in students (Daniel, 2018) however, students frequently question how these skills translate into meaningful, real-world impact. Achieving a balance in providing meaningful relevant experience and delivering theoretical knowledge of research methods can be difficult to achieve (Earley, 2014) yet also has lifelong impact on student learning.

This paper presents a case study of a postgraduate research methods module designed for students across six engineering and business programmes. The case study explains the pedagogical innovation introduced in two stages over two academic years i.e. 2022/23 and 2023/24 to embed education for sustainable development (ESD) principles into the curriculum. The aim is to demonstrate how sustainability can be used as a unifying framework for research methods education to enhance relevance of the content, amplify student engagement and develop transferable skills without overwhelming students or staff. The paper details the practical steps taken, reflect on tutor experience, and highlights the lessons learned for engineering educators seeking to prepare graduates who can both master research methods and contribute to global sustainable development.

2 Literature Review

2.1 Embedding (ESD) in a Postgraduate Research Methods Module

The integration of sustainability in higher education is increasingly guided by the principles of ESD which advocate for the development of key competencies such as systems thinking, anticipatory thinking, strategic competence, and normative competence (UNESCO, 2017). These competencies empower learners to understand sustainability challenges and to contribute to solutions in a critical and creative manner. Berchin et al. (2021) demonstrate that higher education institutes (HEIs) operationalise the attempts to integrate sustainability through a four-pillar model, i.e. knowledge production, curriculum innovation, research and community engagement, however there is often a difficulty in scaling these efforts beyond pilot initiatives. Hence, there is a gap in examining how efforts can be scaled over time and integrated systematically into core academic structures, rather than remaining standalone examples of good practice.

Empirical studies have explored how the UNESCO (2017) competencies can be operationalised across diverse disciplines. For instance, Lozano et al. (2022) surveyed 13 institutions to identify discipline-specific pedagogical approaches that effectively develop sustainability competences. Similarly, Viera Trevisan et al. (2024) conducted a multi-case review of transformative organisational learning processes in HEIs, emphasising the role of institutional change management in embedding sustainability into both formal and

informal curricula. These studies reveal that without deliberate, discipline-specific strategies and sustained institutional commitment, efforts to embed ESD risk remaining superficial or fragmented across higher education. While much of the literature supports integrating sustainability into curricula, recent studies reveal persistent gaps in the depth and consistency of this integration. For instance, (Delaney and Liu, 2023) evaluated postgraduate design courses in the UK and found that over 80% ranked as “weak” or “very weak” in sustainability integration, based on Sterling’s model (Sterling, 2004). This highlights a widespread challenge in translating sustainability commitments into pedagogical practice, particularly in postgraduate education.

Research on module-level interventions has highlighted practical strategies for embedding sustainability into core courses without overloading curricula. Embedding sustainability into higher education requires a rethinking of pedagogical strategies to develop active, critical, and interdisciplinary learning. Reviews of sustainability integration in engineering and education (Delaney and Liu, 2023, Guitierrez-Bucheli et al., 2022), highlight that in addition to curriculum redesign, embedding sustainability effectively also requires a shift toward active and experiential learning approaches, including problem-based learning, contextualised examples, peer collaboration, and reflective practices. Tisdale and Bielefeldt (2024) suggest that while sustainability is increasingly incorporated into core engineering courses, integration often remains technically focused, with limited attention to broader social, ethical, and systemic dimensions. This underscores the importance of articulating clear cognitive and effective learning outcomes, and adopting experiential, application-based methods to foster a sociotechnical mindset among students.

Recent approaches such as Sustainable Design-Based Learning (SDBL) advocate for reconfiguring engineering education through open-ended, sustainability-driven design projects that develop students' capabilities as systemic change agents (Felipe et al., 2023). Berchin et al. (2021) argue for sustainability efforts to move beyond isolated initiatives as institutional support for continuous faculty development and collaborative curriculum design is critical to embedding sustainable development into the core structures of higher education practice. In particular, when considering the integration of sustainability in research methods teaching at the postgraduate level, the challenge lies in embedding ESD competencies in a way that enhances, rather than distracts from, core academic objectives.

Traditional research methods modules often prioritise epistemological understanding, methodological rigor, and academic communication (Earley, 2014). However, without contextual relevance, students may fail to recognise the broader societal implications of their research. By embedding sustainability as a contextual lens through which research is framed and assessed, students can develop a richer understanding of the wider relevance of their learning. Despite ever increasing interest and advances in embedding ESD in higher education, there appears to be little investigation of ESD in a postgraduate research methods module, which is a critical opportunity for students to develop transferable research skills. While existing studies offer valuable insights into discipline-specific and design education contexts, there remains a gap in understanding how to integrate ESD competencies into postgraduate research methods training. Therefore, this paper addresses that gap by presenting a case study of a multi-disciplinary research methods module redesigned to align research skills with ESD competencies.

3 Module Context and Design

3.1 Description of the postgraduate multi-disciplinary research methods module

The focus of this paper is on a research methods module delivered to six postgraduate programmes across engineering and business disciplines at a Russell Group University (Russell Group, n.d). The module is designed to support students in their academic journey, by equipping them with transferrable study, professional and research skills required for successful completion of their final projects and future professional practice. The module is offered in a blended longitudinal format to over 1000 full-time students integrating asynchronous online learning with live synchronous sessions both online and face-to-face. This format provides flexibility for a diverse international cohort while maintaining consistent engagement through the academic year.

The overarching aim of the module is to support students to design and conduct independent, ethically grounded, and methodologically rigorous research. To achieve this aim, the module has several learning objectives focussed on the development of key skills: critical thinking, communication, problem solving, ethical research and analytical skills. Achievement of these learning outcomes is assessed through three individual assessments that evaluate the development of these skills.

The module is inherently multidisciplinary, with learning materials co-developed by Subject Champions who are educators in the department with expertise in engineering, business, and social science disciplines. These Subject Champions in the module team produce discipline-focussed examples and case studies for the module, allowing students to approach threshold concepts (Meyer and Land, 2003) such as academic writing, critical thinking, research ethics, data collection, and data analysis through the lens of their own discipline. The representation of multiple disciplines in the module evidences an inclusive approach to promoting the application of skills in different contexts of knowledge. This multi-disciplinary approach to research methods is a way to prepare students for multidisciplinary collaboration in both academic and applied research settings.

3.2 Embedding Sustainability

The module is delivered by a team of tutors from multiple academic backgrounds, which allowed for a collaborative approach to embedding sustainability. In 2022/23, the module team initiated a strategic redesign to embed sustainability as an over-arching theme throughout the curriculum. Initial team meetings in 2022 focused on raising awareness of ESD among the teaching team, using this as a foundation to co-develop strategies for contextualising sustainability in discipline-relevant ways. These conversations laid the groundwork for a phased approach to integration of sustainability into both teaching and assessment.

The module redesign in 2022 was not intended to transform the module into one *on* sustainability, rather to use sustainability as a contextual framework to enhance the relevance, relatability, and critical dimensions of the research methods content delivered to students from different disciplines. The challenge was twofold: first, to integrate sustainability meaningfully without compromising the delivery of essential content on transferrable skills, i.e. study, professional and research skills. Second, to achieve this integration without

increasing workload for students and academic staff. This led to the development of a constructively aligned approach in which embedding sustainability related content enhanced, rather than displaced, the module's learning outcomes.

4 Implementation Strategy

The integration of sustainability into the module followed a phased, collaborative approach beginning in 2022/23 academic year and is still ongoing. At the time of writing, since the module has not concluded for the 2024/25 academic year, this paper focuses on strategies for ESD implementation for 2022/23 and 2023/24. This strategy focused on embedding sustainability in ways that were research informed and pedagogically grounded, contextually relevant across disciplines, and sustainable to implement for educators.

4.1 Academic Year 2022/23: Laying the Foundations

The initial phase prioritised awareness of sustainability and alignment in defining sustainability for the module team. At the outset, module tutors engaged in professional development sessions aimed at increasing familiarity with ESD and the United Nations Sustainable Development Goals (UNSDGs). These sessions, embedded within regular team meetings, encouraged collaborative reflection on how sustainability can be made relevant to different disciplines without deviating from the aim of the module.

Following these discussions, the team adopted a small teaching approach (Lang, 2021) whereby sustainability themes were used to frame rather than replace existing content. For instance, lectures on research ethics incorporated sustainability-related ethical dilemmas, and examples of research questions and methodologies were drawn from sustainability case studies relevant to engineering and business contexts. To further strengthen this integration, students were given the opportunity during small group teaching sessions such as workshops to apply research methods knowledge with real-world sustainability issues. For example, engineering students examined data collection strategies used in life cycle assessment, while business students analysed survey design in the context of ethical consumerism research.

The assessment for academic year 22/23 required students to evaluate research methodologies in their discipline by identifying a research topic that aligned with at least one UNSDG. This not only deepened their understanding of research design but also introduced them to how their future work could contribute to global sustainability goals.

4.2 Academic Year 2023/24: Deepening Engagement through Applied Assessment

Building on the success of the previous year, the module team continued to embed sustainability examples and case studies in the learning material in the context of research methods. A more ambitious assessment task was introduced in 2023/24. Students were now asked to develop a full research proposal that addressed a real-world sustainability challenge, relevant to their academic and professional interests. This required them to integrate core components of research design such as literature review, methodological justification, and ethical considerations for a complex problem related to sustainability. This task was explicitly designed to support the development of key sustainability competencies identified by UNESCO (2017). Through this assessment students demonstrated anticipatory competence through scenario planning and projecting potential future implications of their research; normative competence by critically reflecting on the ethical dimensions of their proposed studies; and systems thinking by considering how their research topics

connect to broader environmental, economic, or social systems. By requiring students to engage with these competencies in the context of their own disciplinary research, the assessment moved beyond theoretical knowledge, enabling students to develop practical skills essential for addressing complex, real-world sustainability challenges.

To support students in this more complex task, the module team adopted problem-based learning (PBL) approaches, encouraging students to identify real-world issues and work through the research process collaboratively. Reflective prompts were introduced through synchronous student support sessions to help students track their evolving understanding of sustainability in their discipline and its implications for research methodology. This scaffolded, iterative approach ensured that sustainability was not an add-on, but an integrated and meaningful component of the research education experience.

5 Key Reflections and Discussion

Embedding ESD into research methods teaching was found to be both feasible and pedagogically effective using a phased approach for this module. It was achieved by introducing sustainability concepts incrementally, which allowed tutors to maintain a focus on core research skills without overwhelming the curriculum. The development of discipline-specific examples and case studies has been a key factor in reducing preparation time, making the sustainability integration model scalable and sustainable, though it requires ongoing effort to adapt the resources to the evolving field of sustainability (Gutierrez-Bucheli et al., 2022). By reusing and adapting examples from sustainability related research, the teaching team has built a growing database of resources that can be easily integrated into future sessions. Such approach aligns with existing research, which suggests that sustainability integration is most effective when introduced gradually and flexibly, preventing the overcrowding of curricula and enabling students to see sustainability as an integral part of their academic work (Delaney and Liu, 2023; Tisdale and Bielefeldt, 2024). This gradual and flexible approach also mirrors the findings of Sterling (2004) and Pineda, Abu-Hayt and Lindeburg (2023), who argue that sustainability integration requires a balance between depth and scope, ensuring the integration is meaningful and applicable.

On reflection, it has been observed that training and professional development for tutors, particularly in multidisciplinary contexts such as research methods is key to successfully embedding sustainability in a module. The frequent engagement with ESD concepts not only deepened tutors' understanding of sustainability pedagogy but also provided them with additional tools to enrich their teaching. This professional growth allowed educators to effectively bring sustainability into their discipline-specific teaching practices, enhancing the student learning experience. Berchin et al. (2021) Click or tap here to enter text. argue that professional development is key to moving sustainability beyond isolated initiatives, fostering a holistic approach across the curriculum. However, challenges still exist in terms of providing further clarity around ESD goals and offering more targeted professional development. Continued support for tutors is essential to ensure that sustainability principles are effectively integrated into curricula and teaching methods.

The study also highlights the role of collaborative tutor development in sustaining the initiative. Early workshops focused on ESD helped build a shared language and understanding among the teaching team, which ensured greater confidence in incorporating sustainability themes into their teaching. A key component of this initiative was the creation of a discipline-specific resource bank, which made the

sustainability integration model more sustainable by reducing the burden of preparation on individual tutors. This collaborative effort mirrors the work of Berchin et al. (2021) who emphasized the importance of continuous faculty development and support for integrating sustainability into higher education practices. As Meyer and Land (2005) suggest, when educators themselves undergo transformative learning regarding key concepts, in this case sustainability, they are better equipped to embed those concepts into their teaching and to facilitate the same transformation in students.

From a curriculum design perspective, the phased strategy of integrating sustainability into research methods proved effective. The process began with raising awareness about sustainability and progressed to applied assessments that required students to demonstrate their understanding in authentic research scenarios. This strategy helped align sustainability with existing learning outcomes, ensuring that it did not compete with critical research skills but rather enhanced their relevance. By framing sustainability as a context for research rather than an additional content layer, the module successfully maintained a focus on research methods while deepening students' engagement with global sustainability issues (Sterling, 2004). This approach aligns with broader educational trends that advocate for more contextual, interdisciplinary, and experiential learning approaches (Gutierrez-Bucheli et al., 2022).

Finally, achievement of student learning outcomes suggest that embedding sustainability within assessments not only enhanced students' motivation but also increased their ethical awareness without imposing excessive workload. The integration of key UNESCO (2017) competencies—anticipatory, normative, and systems thinking—allowed students to develop critical skills for addressing global challenges. Aligning student work with specific UNSDGs provided a clearer framework for understanding how their research contributes to global sustainability targets. However, students did report challenges in connecting abstract sustainability concepts to methodological choices, suggesting the need for more scaffolded guidance and explicit connections between ESD competencies and the module's learning outcomes. This feedback aligns with research on the importance of clear, contextualized instruction to help students bridge abstract sustainability concepts with practical application (Gutierrez-Bucheli et al., 2022; Tisdale and Bielefeldt, 2024).

7. Conclusion and Recommendations

This case study has demonstrated that embedding sustainability into postgraduate research methods education is both achievable and impactful when approached through contextual integration, scaffolded assessment design, and collaborative staff development. By aligning research skills with the SDGs and enhancing anticipatory, normative, and systems thinking, the module supports students not only in developing analytical expertise but also in understanding their role as future change agents. Although this case study is based in a UK university, the principles of contextual integration and collaborative tutor development are broadly applicable. Institutions worldwide can adapt the framework to their disciplinary strengths and local sustainability priorities. By aligning research methods training with global goals, engineering and business programmes can prepare graduates to address complex challenges of sustainability through the application of analytical skills.

6 References

- Berchin, I.I., de Aguiar Dutra, A.R. and Guerra, J.B.S.O.D.A., 2021. How do higher education institutions promote sustainable development? A literature review. *Sustainable Development*, 29(6), pp.1204-1222. <https://doi.org/10.1002/sd.2219>
- Delaney, E. and Liu, W., 2023. Postgraduate design education and sustainability—An investigation into the current state of higher education and the challenges of educating for sustainability. *Frontiers in Sustainability*, 4, p.1148685. <https://doi.org/10.3389/frsus.2023.1148685>
- Earley, M.A., 2014. A synthesis of the literature on research methods education. *Teaching in Higher Education* 19, 242–253. <https://doi.org/10.1080/13562517.2013.860105>
- Felipe, A., Pineda, V., Abou-Hayt, I. and Lindeburg, A., 2023. Towards a sustainable design-based engineering education. In *Proceedings of the Eleventh International Conference on Engineering Education for Sustainable Development*, Fort Collins, CO, USA (pp. 18-21).
- Gutierrez-Bucheli, L., Kidman, G. and Reid, A., 2022. Sustainability in engineering education: A review of learning outcomes. *Journal of Cleaner Production*, 330, p.129734.
- Lang, J.M., 2021. *Small teaching: Everyday lessons from the science of learning*. John Wiley & Sons.
- Lozano, R., Barreiro-Gen, M., Pietikäinen, J., Gago-Cortes, C., Favi, C., Jimenez Munguia, M.T., Monus, F., Simão, J., Benayas, J., Desha, C., Bostanci, S., Djekic, I., Moneva, J.M., Sáenz, O., Awuzie, B., and Gladysz, B., 2022. Adopting sustainability competence-based education in academic disciplines: Insights from 13 higher education institutions. *Sustainable Development*30(4), 620–635. <https://doi.org/10.1002/sd.2253>
- Meyer, J. H. F., and Land, R., 2003. Threshold concepts and troublesome knowledge: Linkages to ways of thinking and practising within the disciplines. In *C. Rust. (Ed.), Improving student learning – Theory and practice ten years on* (pp. 412-424). Oxford: Oxford Centre for Staff and Learning Development (OCLSD).
- Meyer, J. H. F., and Land, R., 2005. Threshold concepts and troublesome knowledge (2): Epistemological considerations and a conceptual framework for teaching and learning. *Higher Education*, 49(3), 373-388.
- Russell Group (n.d.) Our Universities Available at: <https://www.russellgroup.ac.uk/our-universities> (Accessed on: April 23, 2025)
- Sterling, S., 2004. Higher education, sustainability, and the role of systemic learning. In *Peter Blaze Corcoran & Arjen E.J. Wals (Eds.), Higher education and the challenge of sustainability: Problematics, promise, and practice* (pp. 49-70). Dordrecht: Springer Netherlands.
- Tisdale, J.K. and Bielefeldt, A.R., 2024. Exploring Sustainability Instruction Methods in Engineering Thermodynamics Courses: Insights from Scholarship of Teaching and Learning. *Sustainability*, 16(19), p.8637.
- Viera Trevisan, L., Leal, W. and Ávila Pedrozo, E., 2024. Transformative organisational learning for sustainability in higher education: A literature review and an international multi-case study. *Journal of Cleaner Production*, 447, 141634.
- QAA/Advance HE (2021), “Education For Sustainable Development Guidance”, Quality Assurance Agency for Higher Education and Advance HE, available at: <https://www.advancehe.ac.uk/knowledge-hub/education-sustainable-development-guidance> (accessed 23 April 2025)