Education for Sustainable Development (ESD): A holistic approach to curriculum design, development and implementation using participatory and integrative methodologies

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SUMMARY

In response to the climate emergency and future Sustainable Development (SD) of our planet, HEIs must adopt integrated, holistic approaches to curriculum design that are primarily focused on developing graduates into more socially responsible, global citizens and engineers with sought-after sustainability competencies and skills, empowered to tackle complex local and global SD challenges. In line with our institutional strategic goals and commitments, we outline the use of innovative, participatory programme design methodologies involving internal and external stakeholders, in our approach to designing a new post-graduate course in Sustainable Engineering at Aston University that has the potential to fulfil these transformative goals, asking ourselves and all stakeholders throughout: "What content really matters?" "Are students doing something that is meaningful?" "How should it be taught?". This work describes the implementation of our innovative ESD approaches to holistic curriculum design, development, implementation, and delivery. Using evaluation data from staff, students, and external stakeholders the effectiveness and impact of these programme design and delivery approaches are evaluated, and the findings are presented. Highlighted areas of good practice, as well as key lessons learned in our work can serve as potential signposts for other HEI adopters of similar or other ESD methodologies.

INTRODUCTION

In the face of the escalating climate emergency and the imperative for sustainable global development, Higher Education Institutions (HEIs) opportunely stand at the forefront of driving change. The urgency to equip graduates with the essential skills and competencies to address complex sustainable development (SD) challenges has never been more pressing (Rieckmann, 2018; UNESCO, 2022). To meet this demand, HEIs must adopt integrated and holistic approaches to curriculum design that prioritize the development of socially responsible, globally aware engineers. This paper presents a pioneering endeavour at Aston University, where we have embarked on a transformative journey towards this vision.

Aligned with our institutional strategic objectives outlined in the Sustainability and Education Strategies (Aston University, 2020, 2021), we introduce a comprehensive framework for designing a post-graduate course in Sustainable Engineering. This framework hinges on innovative, participatory methodologies that engage both internal and external stakeholders. Throughout this process, we continually assess both what is taught and how it is taught by posing critical questions such as: "What content truly matters?" "Are students engaged in meaningful activities?" "How can we best facilitate learning?". This stems from the recognition that whilst ESD has the potential to transform graduate outcomes and the student experience of HE courses (IEMA 2017; QAA, 2021), if not integrated appropriately, a well-intended ESD initiative can lead to a non-substantive and a reductionist pedagogy (Seatter and Ceulmans, 2017). These inquiries serve as guiding beacons, steering us towards a curriculum that not only imparts knowledge and equips students with industry-sought professional skills and key competencies in ESD, but also instils a profound sense of responsibility as engineers, scientists, and technologists towards our planet's sustainable future (Booth et al., 2009).

With respect to embedding sustainability within HE curricula, there are three different levels of change strategies commonly associated with ESD in the literature that include ‘add-on’ or education *about* sustainability, ‘integration’ or education *for* sustainability and ‘transformation’ or education *as* sustainability (Sterling, 2011; Kolmos et al., 2016; Rosen et al., 2019). On a practical level, these 3 strategies can be more simplistically perceived as change at modular, course/programme and institutional levels, respectively, where the latter requires a transformational or ‘re-building’ approach. Here, we propose that the methodology we outline is well situated as a steppingstone between the required course and institutional levels of change, providing a model that can be followed at course level and up to accelerate the pathway to holistic institutional transformation for ESD.

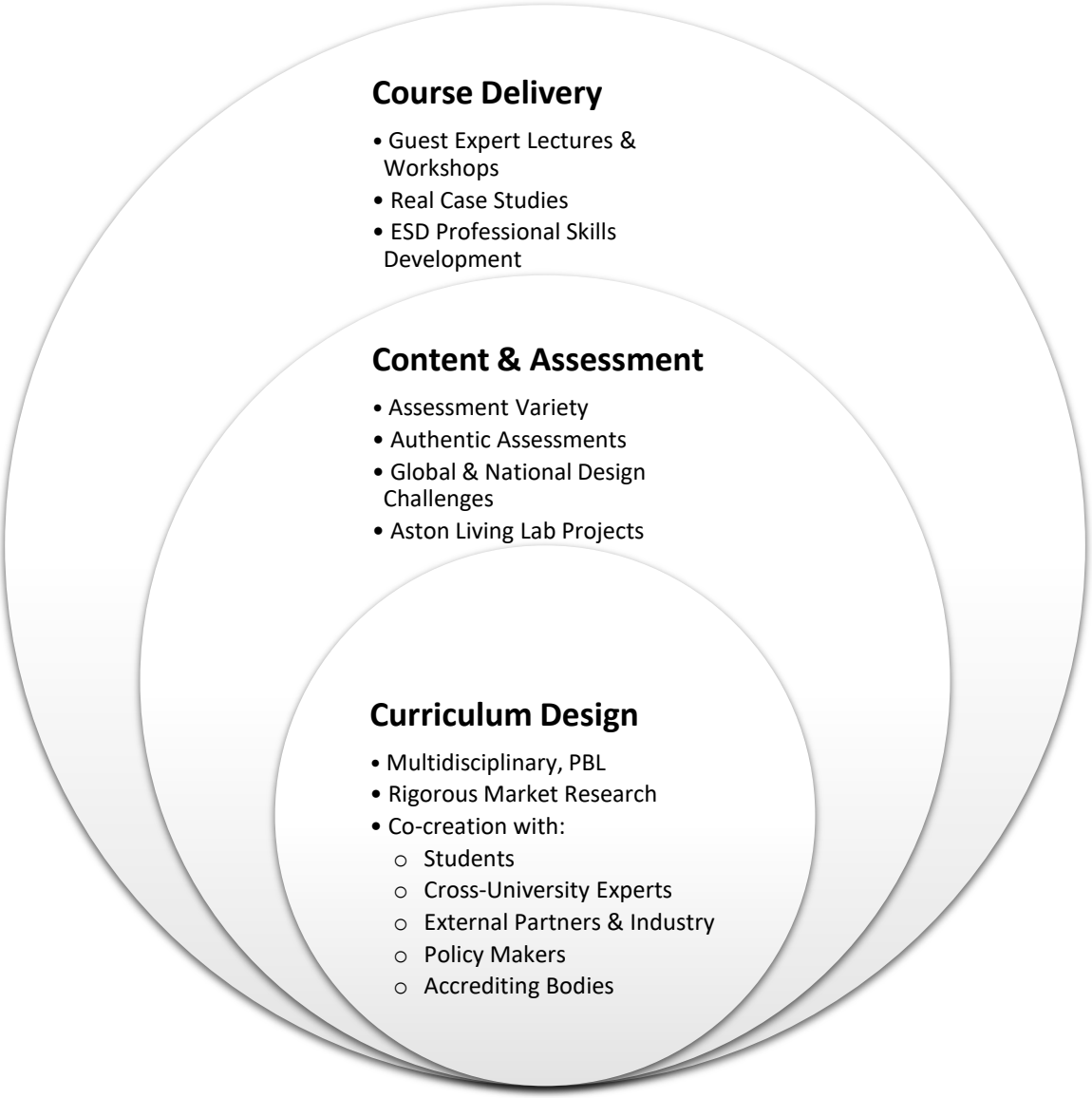
This work encapsulates the implementation of our holistic curriculum design, development, implementation, and delivery, firmly anchored in ESD principles (Rieckmann, 2018). Through evaluation of preliminary findings, drawing insights from feedback provided by faculty,

students, and external partners, as well as through internal and external course evaluation metrics, such as module evaluation surveys and the national Postgraduate Taught Experience Survey (PTES), respectively, we assess the efficacy and impact of our program design and delivery approaches. These findings are presented here, highlighting areas of exemplary practice that have emerged from our undertaking. Additionally, invaluable lessons we've gleaned along the way are also shared. Our intention is that these insights will serve as guiding markers for other HEIs looking to embrace similar ESD methodologies or seeking innovative approaches to curriculum design in the pursuit of embedding sustainability from the outset of their course development in what needs to be a sector wide, concerted effort to sustainable global development. As the HE sector navigates this critical juncture in education and sustainable engineering, the journey undertaken by Aston University stands as a testament to the power of collaborative, forward-thinking pedagogical practices. Together, we embark on a mission to not only educate, but to inspire a new generation of engineers equipped to tackle the intricate, global challenges of sustainability, for the betterment of our world.

DESIGN AND DEVELOPMENT OF THE ESD CURRICULUM

In September 2021, we launched an innovative, multi-disciplinary post-graduate degree in Sustainable Engineering in the College of Engineering and Physical Sciences (EPS), the Engineering Faculty at Aston University. This MSc course was conceptualised and designed with the aim of bridging the significant engineering industry gap identified in sustainability skills (IET, 2021), through sector-informed content and approaches that target the development of key technical, transferrable, and professional SD skills and competencies. The methodologies implemented in curriculum design, development and delivery are summarised in Figure 1.

Figure 1. Overview of Implemented Curriculum Design and Delivery Framework



CURRICULLUM DESIGN PROCESS

The course design, development, and delivery centred on the implementation of integrative and transformative ESD throughout the whole process. Holistic curriculum design was achieved through several approaches that involved:

1. Rigorous market research that extended beyond the UK and entailed surveying and analysis of the provision of any similar competing courses amongst UK HEIs, as well as HEIs across Europe and North America.

2. A constructivist approach to co-design, where internal and external stakeholders were engaged throughout the curriculum design and development process providing crucial guidance in decision-making (Wilson and Slade. 2020; Mohedas et al., 2023). A wide variety of both internal and external stakeholders were engaged including:

    i. Targeted student focus groups and interviews, where students from a wide variety of undergraduate and postgraduate Engineering and Business-related programmes were invited to take part in in-depth discussion of the programme and to elicit detailed feedback on programme concept, content and delivery strategies, professional accreditation plans, external partners and rate their interest on enrolling on such a course. Four focus groups and one interview were carried out where a total of 18 students (55% male, 45% female) participated. This approach facilitated a better understanding of our key stakeholders' views and needs in relation to aspirational programmes of study, as also highlighted by (Belita et al., 2020, and Bovill, et al., 2023).

    ii. Four consultation rounds over a period of six months with external stakeholders from key non-profit and private organisations active in the environment and sustainability sectors, including Engineers without Borders UK, Energy Systems Catapult, and the Carbon Trust, amongst others. These entailed board room style meetings of various durations, as well as sustained electronic communication over the same period. Moreover, a number of consultation rounds were held with two relevant professional accreditation bodies, including three online meetings with the Institute of Environmental Management and Assessment (IEMA) and electronic communication exchanges with the Institution of Engineering and Technology (IET). This extensive external consultation exercise enabled tailoring and mapping of curriculum content, assessment and delivery to harnessing industry-sought professional skills and graduate expectations. (Hart, et al. 2009; Wilson and Slade, 2020).

    iii. Research institute leaders and academic staff from across the University with world-leading research activity in sustainable development in engineering, science and technology, business, logistics and engineering management, thus ensuring research led curriculum content and Learning and Teaching (L&T) practices.

COURSE STRUCTURE, CONTENT, DELIVERY AND ASSESSMENT METHODS

Our market research and extensive stakeholder engagement in the curriculum design process informed the course content, delivery and assessment methods and ensured a programme of study that incorporated a broad range of elements required to achieve our intended goals of a transformative experience for the learners. The delivered content

centred around sustainability and engineering for sustainable development, the UN SDGs (UN, 2016), the circular economy, technology & policy paths towards achieving Net Zero, Renewable Energy, UK and global Environmental Regulatory Frameworks, Lifecycle Analysis entailing practical training in conducting Life Cycle Assessments (LCA), Environmental Impact Assessments (EIA) and Strategic Environmental Assessments (SEA), as well as Project Management and Supply Chain Management to equip students with essential management skills.

A wide variety of assessment methods were incorporated into the design of the MSc programme that included real world case studies provided via our partner network, open-ended coursework assignments and reports, presentations, project pitching, poster presentations, video presentations, software simulations, peer-assessment and self-assessment, online tests and examinations. The assessment methods entailed extensive incorporation of Problem Based Learning (PBL) and Challenge Based Learning (CBL) activities and assessments (Thomas, 2009). This translates into widespread integration of meaningful authentic assessments, such as real-world Engineering Design Challenges (Bourn and Neal, 2008). Through our existing partnerships with NGO organisations, such as Engineers without Borders (EWB) UK, and major employers, such as Severn Trent Ltd, we have embedded National and International Engineering Design Challenges (EWB UK, 2023) as credit-bearing assessments in the curriculum. These design challenges feature open design briefs of real-world problems, such as community-based, sustainable development projects, and sustainable development challenges faced by the water industry.

Our previous work highlights how significantly students have benefitted from the adopted ESD approaches in L&T through the development of their professional and transferrable skills in communication, teamwork, leadership, critical thinking, and innovation (Poursharif et al., 2021). In addition, to ensure the currency and impact of student dissertation projects, the course design enables students to engage and collaborate with world-leading engineering research at Aston University. Students also have the opportunity to make an impact while they study through our initiative with the university Estates Department in utilising the campus as a Living, Net-Zero Lab for their major projects, an approach which has been reported to promote innovation and sustainability and contribute directly to UN SDGs (Compagnucci, et al, 2021; Molinari, et al., 2023).

Our approach to course delivery focused on facilitated sessions in multidisciplinary group settings fostering collaborative skills (Braßler, and Sprenger, 2021) through peer-instruction and peer-learning and the development of critical awareness, problem solving skills and the ability to tackle ‘wicked’ problems (QAA, 2014). Due to the rapidly evolving nature of the topic and developments in the field, the delivery strategy also placed great importance on extensive use of embedded seminars and workshops on technical content and leading global SD issues delivered by guest scholars, industry experts and policy makers from our external

partner network, thus ensuring the currency and relevance of the delivered content. In addition, professional skills and employability workshops are embedded in the timetable at regular course intervals. Moreover, at least one field/site visit is organised per term in collaboration with our industrial partner network, which serves the purpose of consolidating classroom learning, while inspiring and motivating students, and providing the opportunity to be immersed in real work settings (also a welcome change of scenery!).

EVALUATION

In this section we outline the methods implemented to evaluate our curriculum design, development and implementation approach. These methods are distinctly outlined, firstly as part of the validation stages of the programme (pre-implementation) followed by its delivery (post-implementation). In both stages, evaluative feedback from internal and external stakeholders of the MSc programme is presented. Where such verbal feedback is provided, it is feedback that was not directly requested, but rather naturally occurring and shared anonymously as part of the continuous course monitoring and enhancement processes at the university. As such, no separate ethics approval was required for this aspect of the work. In the post-implementation stage, evaluation is carried out through analysis of module evaluation questionnaires (MEQs), student self-evaluation survey results on their experience of participating in the embedded International Design Challenge, and the results obtained from the UK national Post Graduate Taught Experience Survey (PTES). Moreover, in terms of external validation, our MSc programme was awarded professional accreditation within eleven months after the course was launched, which is one of the key testaments to the success of the approaches taken in its design, development and implementation, resulting in the desirable outcome of equipping students with the professional registration required upon completion that can significantly impact their career development and future success.

PRE-IMPLEMENTATION

The MSc course was the first programme in the College of EPS to have ever been approved by the University's Programme Specific Approval Panel (PSAP) without conditions, receiving very high commendations and continues to be used as one of the best examples of programme design by the University Quality Team. The commendations received in this respect are a testament to the extensively participatory curriculum design process in the six month pre-validation stage and the success of the approach implemented by the programme team:

"Excellent due diligence in the design of this programme with a lot of discussion with industry and student focus groups. Due to the excellent documentation, the market research, focus groups and the well design of the programme the panel were easily able to make an informed decision regarding the programme." PSAP Chair, Aston University, 2021

POST-IMPLEMENTATION

Since the launch of the MSc programme, the course modules have consistently received excellent feedback and high overall module satisfaction scores, which were obtained via the module evaluation questionnaires (MEQs) centrally administered by the university for all courses. As a standard practice, MEQs evaluate student perspectives on the module with respect to content, clarity and achievability of learning outcomes, delivery mode, academic support, engagement, and assessment and feedback. The average module satisfaction score obtained across all module MEQs on the MSc programme over both 2021/22 and 2022/23 was **4.4 / 5.0**. In particular, new modules that are unique to the MSc programme in the university, such as Sustainability in Engineering Practice, Pathways to Net Zero, Environmental Regulations & Impact Assessment performed exceptionally well, all averaging in the range of **4.5-4.7 / 5.0**.

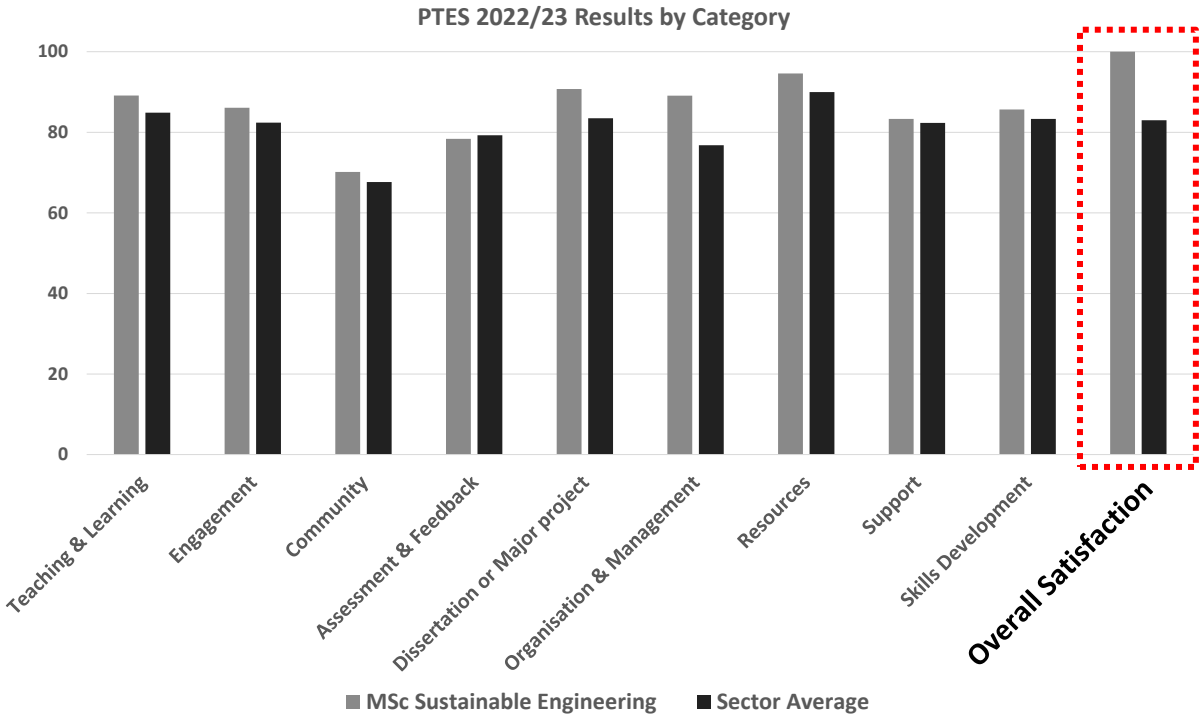
Students attending our MSc course in 2022/23 were surveyed on their own reflective experience of participating in the embedded International Design Challenge after its completion. This aspect of the research work was conducted with full ethical approval by the university's Engineering & Physical Science's Research Ethics Committee. The self-evaluation survey had a response rate of 81% and the results are currently under final review and analysis, and will be published separately. However, an initial appraisal of preliminary results revealed that our implemented methodology of multi-disciplinary group PBL/CBL assessments and immersion into an International Engineering Design Challenge has significantly impacted either the majority or all of the respondents in all of the respective sections where it was seen that our approach has:

1) Boosted their confidence levels in their skills of problem solving, creative thinking, making ethical decisions and communication.
2) Increased their abilities to be flexible in their approach to professional problem solving, consider different aspects of sustainability within their professional work and account for user-centred design in devising solutions to complex sustainable development problems.
3) Developed the extent to which they consider the perspectives of others in their decision-making and consider as the consequences of their professional.

The Post Graduate Taught Experience Survey (PTES) is a national survey carried out in the UK to evaluate PGT student satisfaction and enables HEIs to compare against sector benchmarks. Although not used in HEI league tables, the PTES is helpful as an evaluation tool for institutional development of their PGT offering (Muijs and Bokhove, 2017). The PTES evaluates both institutional and programme characteristics, but the lines between these two dimensions may not be as clear cut and therefore impacts the granularity of data at programme level, requiring care in data interpretation. Despite this, when reviewing programme level statistical results, the PTES offers a reasonable insight into student perspectives on their overall programme experience including sections with grouped core statements related to Learning & Teaching (L&T), assessment and feedback, engagement, dissertation or major project, organisation and management, resources and services, skills development, amongst other more socially oriented variables and metrics. The open-text student feedback provided in each of these core statements or categories can further refine the analysis of PTES data by offering course specific comments and constructive criticism that enhance our continuous programme development efforts.

For our MSc in Sustainable Engineering, the PTES conducted in 2022/23 had a response rate of 87.5% from the 24 eligible participants. A summary of results obtained is provided in Figure 2, where these are presented as the average score for each PTES core statement category contrasted against the reported sector average.

Figure 2. Summary of PTES 2022/23 Results by Category for MSc in Sustainable Engineering



On average for most PTES core statement categories, the satisfaction scores for the MSc in Sustainable Engineering exceeded the sector average. The overall satisfaction score for the MSc programme was **100%**, compared to the sector average of **83%**. In the Assessment and Feedback section, our MSc scored an average of 78.38% which was slightly below the 79.25% sector average. Although our average here was higher than the Aston University and our College of EPS averages of 74.50% and 72.25%, respectively, the PTES results highlighted Assessment and Feedback as an area for further scrutiny and improvement within our MSc programme. A detailed review of the core statements within this PTES section showed that our MSc scores significantly exceeded both sector and local averages in most core statements, except "Assessment arrangements and marking have been fair" where the average score for our MSc was 61.5% compared to the sector, university and EPS scores of 77%, 71% and 66%, respectively. Textual student feedback was not provided in this section and a re-examination of all available module MEQs did not indicate any significant student issues or concerns within the equivalent MEQ assessment categories or written feedback provided. However, evidence gathered from formally minuted Student Staff Committee meetings pointed to a potential correlation between this low PTES core statement score and voiced student dissatisfaction with mitigating arrangements made for an assessment element within an EPS College-wide module offered on our MSc, which was due to a staff resourcing issue that impacted a number of other programmes as well (as may also be evidenced from the EPS College average of 66%, which was also below sector and University averages). Although this particular matter was beyond the direct control of our programme, the circumstances around it, in combination with textual responses to the PTES, led to positive actions being taken towards our course development, including:

1. The establishment of enhanced lines of communication between our programme and the multiple programmes/departments that are naturally involved in the delivery of College-wide modules.

2. A re-evaluation of technical aspects within our course content and our overall assessment strategy based on student feedback; when asked to comment on "One thing that would most improve your experience of your course" some examples responses included:

    - "…the grading criteria [of the course] to be reviewed"
    - "…not as much coursework possibly…"
    - "More practicality…in engineering terms with in-depth knowledge".

Where available, written feedback provided in the PTES was generally excellent and highly encouraging. For example, when asked to answer "One thing that has been most enjoyable or interesting about your course" some of the responses obtained from the 2022/23 PTES are shown in Figure 3 below:

Figure 3. PTES 2022/23 MSc Sustainable Engineering Programme Responses to "One thing that has been most enjoyable or interesting about your course"

Naturally occurring, anonymised feedback obtained from students generally matched formal feedback obtained via PTES. Of particular mention, is one student's feedback that encapsulated the intended success of our methodology and affirmed its envisioned impact:

"The journey of studying MSc Sustainable Engineering over the past year has been nothing short of transformative. I can confidently say that I have evolved into an upgraded version of myself, both academically and professionally. It is through the guidance and support of you and of all the teachers I came in touch with that I have been able to navigate this path. I believe that my aspirations for this course will be fulfilled, and it will undoubtedly pave the way for a smooth and bright future. I owe a great deal of my growth to the dedicated educators I've had the privilege to learn from during my degree." MSc Sustainable Engineering student, 2022/23

DISCUSSION

The implementation of a holistic, ESD focused approach to curriculum design for the MSc in Sustainable Engineering at Aston University has yielded promising results, as evidenced by the pre-implementation and post-implementation evaluations. The discussion section will focus on key findings, implications, and areas for further consideration.

PRE-IMPLEMENTATION SUCCESSES

During the pre-implementation phase, the programme design process was commended for its due diligence, extensive market research, and stakeholder engagement. This commendation from the Programme Specific Approval Panel (PSAP) underscores the effectiveness of the participatory approach in ensuring a well-informed curriculum. The PSAP's recognition of the documentation and market research affirms the value of a comprehensive, evidence-based approach in holistic course design.

POST-IMPLEMENTATION SUCCESSES

The post-implementation phase has demonstrated positive outcomes across various dimensions. The high module satisfaction scores indicate that students are engaged and content with the course offerings. Notably, modules unique to the MSc programme such as “Sustainability in Engineering Practice” and "Environmental Regulations & Impact Assessment" received particularly high satisfaction ratings, suggesting that these components are meeting or exceeding students' expectations. These results validate that the course content aligns well with the needs and interests of the students.

Moreover, the self-evaluation survey on the embedded International Design Challenge reflects a significant boost in students' confidence levels in various key skills, including problem solving, ethical decision-making, and communication. Overall, students self-reported that they are more confident in their ability to bring sustainable engineering solutions to real-world problems as a direct result of taking part in this design challenge, thus developing some of the key ESD skills (Rieckmann, 2018; Rosen et al., 2019) that serve in augmenting their employability profile as more socially responsible, global citizens and engineers with sought-after sustainability literacies, empowered to tackle complex local & global SD challenges.

These results indicate that the integration of Problem Based Learning (PBL) and Challenge Based Learning (CBL) activities has been successful in enhancing students' practical skills and competencies. The positive impact on students' abilities to consider sustainability aspects and user-centred design further supports the effectiveness of the curriculum in promoting sustainable engineering practices.

The exceptional results from the Post Graduate Taught Experience Survey (PTES) further validate the success of the programme. The satisfaction scores surpass sector averages in all categories except one which was only marginally lower, indicating a high level of

contentment among students. Notably, the "Overall Satisfaction" score of 100% is a remarkable achievement, indicating that students are highly satisfied with their experience in the MSc programme. The positive feedback from students emphasizes the value they place on interactive and engaging learning methods, as well as the significance of group activities and collaborations with academic staff and industry.

With regards to MSc graduate outcomes in terms of employability, formal data is not yet available, however, through our existing links with alumni from the 2021/22 (graduated in July 2023) and 2022/23 (graduating in July 2024) cohorts we have witnessed high employability rates amongst our graduates, where a significant proportion (~46% of 2021/22 cohort and ~55% of 2022/23 cohort to-date) are now already working in engineering and sustainability related roles in consultancy firms and industry, particularly within the utilities sectors of energy, electricity, gas and water, where some of our graduates hold roles as sustainability experts and managers on national and international sustainable development projects in their respective industries. Moreover, our alumni are regularly invited as guest speakers on our MSc in very well-received sessions by current students to present projects they are or have been involved in in their workplace, and in addition relay their own experiences of the MSc course and give valuable advice to their peers on managing assessment timelines, dissertation projects and highlight any content, tools and methodologies delivered in the MSc course that they believe have been crucial in their own professional success stories.

CONCLUSIONS & RECOMMENDATIONS

The success of this holistic approach to curriculum design holds several important implications for engineering education for sustainable development (ESD):

1. **Stakeholder Engagement**: The extensive engagement of both internal and external stakeholders has proven instrumental in shaping the curriculum and its success underscores the importance of engaging diverse perspectives, including those from industry, academia, as well as the student community, in ensuring a well-rounded programme of study that aligns with real world needs and expectations. Moreover, collaboration with industry stakeholders provides insights into current sector trends, emerging technologies and methodologies, and workplace demands. This alignment enhances the programme's relevance, equipping students with skills sought after in the respective professional landscape.

2. **Authentic Assessment Methods**: The integration of real-world case studies, engineering design challenges, and practical assessments has been pivotal in

developing students' practical skills. These approaches go beyond traditional assessment methods and allow students to apply theoretical knowledge to practical scenarios, fostering problem-solving skills and preparing them for the complexities of working in multi-disciplinary sustainable engineering projects at a global scale. The emphasis on practical assessments ensures that graduates not only possess theoretical knowledge but also have the hands-on skills necessary for effective implementation in real world situations. Therefore, this aligns with industry expectations and enhances graduate employability.

3. **Integration of UN Sustainable Development Goals (SDGs)**: Explicitly connecting the curriculum to specific SDGs provides a clear roadmap for addressing global challenges and thus enhances the programme's overall impact on sustainability. Aligning coursework with the SDGs augments the programme's societal impact and reinforces the significance of engineering in contributing to broader sustainable development objectives. Furthermore, integrating SDGs encourages cross-disciplinary collaboration, fostering a holistic approach to solving complex issues. This prepares students to work across traditional boundaries, contributing to the interconnected and multidimensional nature of sustainable development challenges.

4. **Global Perspective**: The International Engineering Design Challenge component has been highly beneficial in broadening students' global perspectives and contributes to the development of their cultural competence. Exposure to global challenges and collaboration with peers from diverse backgrounds prepares students to work in multicultural environments; a critical skill in addressing complex, global sustainability issues. Encouraging further international collaborations and opportunities for experiential learning expands students' horizons and fosters a global network of future engineers. This exposure to different perspectives and methodologies enriches their educational experience and contributes to a more interconnected global engineering community.

5. **Continuous Monitoring and Evaluation**: The use of surveys, feedback mechanisms, and ongoing course evaluations has been critical in ensuring the effectiveness of the programme, providing an opportunity for agile curriculum development. This practice of continuous monitoring and evaluation ensures the curriculum remains dynamic and responsive to evolving educational and industry landscapes. Regular feedback mechanisms enable swift identification of areas for improvement, allowing for timely, *in-situ* adjustments to meet the changing needs of students and the engineering field. This resulting iterative process allows educators to incorporate emerging trends, technological advancements, and feedback from students and stakeholders, ensuring the curriculum stays at the forefront of sustainable engineering education.

6. **Dissemination of Best Practice**: The successful course outcomes and positive feedback provide a strong foundation for sharing best practices with other HEIs seeking to implement similar ESD methodologies, and in this way promotes a collective sector approach to advancing engineering education for SD. This knowledge sharing can naturally take the form of conferences, publications, or collaborative initiatives, fostering a community of educators dedicated to driving positive change in engineering education. By establishing, expanding and further cultivating collaborative networks among institutions, this will further facilitate the exchange of experiences, lessons learned, and innovative strategies. Consequently, collective efforts like this can serve in accelerating the adoption of effective ESD methodologies across the broader educational community.

In conclusion, the comprehensive approach to curriculum design and implementation within the MSc Sustainable Engineering programme at Aston University is suggested to be effective in preparing graduates for addressing intricate sustainable development challenges, as indicated by our alumni connections. The favourable outcomes observed in student satisfaction, skills advancement, and broadened global perspectives lend support to the value of the methodologies employed. These findings, therefore, offer a meaningful contribution to the wider discourse on engineering education for sustainable development and provide guidance for other institutions considering to embark on a similar transformative journey. The implications outlined for ESD in engineering education emphasize the need for a holistic, adaptive, and globally conscious approach. By embracing these principles, educational institutions can play a pivotal role in shaping a new generation of engineers equipped to address the multifaceted challenges of sustainable development.

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