ŌTAUTAHI CHRISTCHURCH AOTEAROA NEW ZEALAND
35TH AUSTRALASIAN ASSOCIATION FOR ENGINEERING EDUCATION ANNUAL CONFERENCE
8-11 DEC 2024
THE ENGINEER AND THE WORLD

Review of the Sustainability Inclusion in the Bachelor of Engineering with Honours Degree 2021 vs 2024

Anna Wrobel, Sarah Lyden
University of Tasmania, College of Sciences and Engineering, School of Engineering
Corresponding Author Email: anna.wrobeltobiszewska@utas.edu.au

ABSTRACT

CONTEXT
Sustainability has been recognised as a crucial part of modern engineering education, and numerous attempts have been made in recent years to effectively embed it in engineering Degrees around the World. While both enablers and barriers to effective implementation have been identified, the actual situation differs among higher education organisations in the Asian-Pacific region. The more we understand about both the common enablers and common barriers to authentic implementation of sustainability, the higher chances we have of effective implementation of sustainability in our environment.

PURPOSE OR GOAL
This paper reviews the number of units in the Bachelor of Engineering (specialisation) with honours degree that have been reported to have sustainability included in them. The authors make a comparison between the same units, reported in 2021 and 2024 and comment on the difference found in those two datasets.

APPROACH OR METHODOLOGY/METHODS
The first dataset was based on the authors of this paper collecting data manually for all the units offered in the degree. The later dataset was created as a result of a university wide sustainability survey. While the overall method was slightly different for both datasets, the questions asked in both were similar, consequently the answers were comparable.

ACTUAL OR ANTICIPATED OUTCOMES
In the comparison between two data sets we observed that a smaller number of units were reported to be aligned with sustainability in 2021, in comparison with 2024 datasets. We also noted that the range of SDGs mentioned in the units' report was wider in 2021 in comparison to 2024.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY
We speculate that the differences in the number of units aligned to sustainability and SDGs mentioned in 2021 and 2024 datasets are most likely related to the differences in data collection. Nevertheless, we acknowledge that the number of sustainability-related units is not overwhelmingly high and that by exchanging the experience among different higher education institutions we might make the sustainability inclusion more authentic and widespread.

KEYWORDS

Sustainability, SDGs, degree inclusion

Introduction

Sustainability is considered a key foundational area for engineering practice, as engineers should integrate environmental, social, and economic factors into their designs and solutions. The EA code of ethics, which provides values to guide the engineering profession in Australia, highlights, as one of the four areas, the importance for engineers to 'promote sustainability' (EA, 2019).

Many engineering developments have historically led society towards an un-sustainable consumption of resources from a continual drive to improve technologies and constantly develop and improve standards of living. While technology and innovation have the potential to improve outcomes for society, many technologies have been implemented without consideration for the social, economic, and environmental consequences (Qureshi & Nawab, 2016). Worldwide a shift has occurred in recent years to promote sustainable practices in engineering, in particular around the framework of the UN Sustainable Development Goals (SDGs) and implementing those in Higher Education (Sterling et al.2013). Key examples include the World Federation of Engineering Organisations encouraging the integration of the UN SDGs in engineering work (World Federation of Engineering Organisations, 2021), and the key presence of sustainability as an element of the Engineers Australia code of ethics (Engineers Australia 2019, Engineers Australia 2021).

Wrobel et. al (2024, in review) identify that individual staff and their commitment to achieving certain goals is instrumental to achieving the common university goal of embedding sustainability. Change resistance, staff and student understanding the relevance of sustainability, and non-genuine integration were identified as some key challenges to embedding sustainability (Barth et al. 2013, Gale et al. 2015). Opportunities or enablers for more effective sustainability education included interdisciplinary collaboration, using a common language, and having clear expectations to drive change (Menon and Suresh, 2022). Compared to other disciplines, engineering, with the EA code of ethics clearly embedding sustainability, as a profession has ample opportunity to lead the way in the integration of innovative approaches to developing student conceptual understanding and capability to apply sustainability in their future careers.

The context within which our future graduates will work is increasing in complexity socially, economically, and environmentally. Our graduates need to be well aware of global and local challenges and have the skills and capability to deliver sustainable solutions (Wrobel and Lyden, 2022). To build this skill set, engineering curricula which puts sustainability and sustainable development at the centre is key, and we can learn from initiatives like "Engineering for One Planet, which sets the framework for authentically including sustainability in Engineering courses (EoP, 2024).

The authors of this paper previously conducted a review in 2021 to assess the current state of sustainability integration in the engineering curriculum at a regional Australian university (Wrobel and Lyden, 2022). The findings of that study identified that there were some elements of the curriculum where sustainability was being well integrated, across a wide range of UN SDGs. Since the original study was conducted, a push to integrated sustainability into all year 1 units (with a future aspiration to integrate into all units), was initiated within this engineering school. At a university level, a drive to lead in climate action, and demonstrate a commitment to the SDGs through identifying alignment of every unit within the university to relevant SDGs was undertaken. We now return to our original analysis and take a detailed look at the current state of integration of SDGs to assess how much progress has been made and opportunities for where we can do better.

This paper will outline the degree context for the study, the approach taken, key results and a discussion of where to next.

Degree context

The Bachelor of Engineering (specialisation) with Honours degree is a 4-year full time undergraduate degree with four specialisations. These specialisations are within the three main fields of engineering – civil, mechanical, and electrical, with the latter one further divided into more specific specialisations. University of Tasmania (UTAS) is a mid-size University, placed almost exactly in the middle, out of 40 Universities, in terms of total enrolments. UTAS holistic approach to sustainability is a crucial part of the University's Strategic framework, and was demonstrated, among others, by the University wide survey that investigated sustainability alignment in every unit offered at UTAS. As a part of university policy, a significant effort was made in 2023 to embed sustainability in every unit that is offered at UTAS.

From the course philosophy, the degree seeks to educate engineers who are "committed to crafting modern engineered solutions that are sustainable, economically feasible, safe, and appropriate to context and purpose" (UTAS, 2024). Sustainability concepts and a strong encouragement to truly embed it throughout the whole degree is also reinforced in Engineers Australia Competencies indicators of attainment, (Engineers Australia, 2021) namely:

1.5 b: Identifies and understands the interactions between engineering systems and people in the social, cultural, environmental, commercial, legal, and political contexts in which they operate, including both the positive role of engineering in sustainable development and the potentially adverse impacts of engineering activity in the engineering discipline.

1.6 e: Appreciates the formal structures and methodologies of systems engineering as a holistic basis for managing complexity and sustainability in engineering practice.

2.3 b: Addresses broad contextual constraints such as social, cultural, environmental, commercial, legal political and human factors, as well as health, safety, and sustainability imperatives as an integral part of the design process.

2.4 f: Demonstrates commitment to sustainable engineering practices and the achievement of sustainable outcomes in all facets of engineering project work.

Approach

In this paper we are comparing the results obtained at two separate times, the first in 2021 (Wrobel and Lyden, 2022)) involved personal communication with unit coordinators and the second in 2024, based on the STARS (Sustainability Tracking, Assessment and Rating System) University-wide results.

In 2021 the authors of this paper reviewed all the units offered by the School of Engineering within the Bachelor of Engineering with Honours (Specialisation). The review involved looking through the Unit Outline and having a conversation with Unit Coordinators (UC) to determine whether the Unit has any elements of Sustainability present in it, and then linking relevant SDGs to units. These results have been presented in a book chapter authored by the authors of this paper (Wrobel and Lyden, 2022).

2024 data

In 2022 UTAS issued a university wide survey as a result of participation in a well-known framework used by universities worldwide to assess Sustainability Tracking, Assessment and Rating System (STARS). The completion of the survey was done by UCs, for each specific unit separately, where UCs nominated their unit as 'sustainability- focused', 'sustainability- inclusive' or 'not sustainability-aligned' and nominate specific SDGs) that are linked to the unit. It is important to note that staff was not given any more detailed instructions before they were asked to complete the survey. The data from that survey was available in 2023 and made public by inclusion in the course and unit handbook in 2024.

To compile the novel data that we are presenting in this paper we investigated the public results of the survey, available on the UTAS website.

Results and Discussion

2021 Data and results

In the review of sustainability in the Degree completed in 2021 by the authors of this paper, 11 units across the degree program were identified which had notable alignment to the SDGs. The spread of SDGs aligned with units are shown in Figure 1, below.

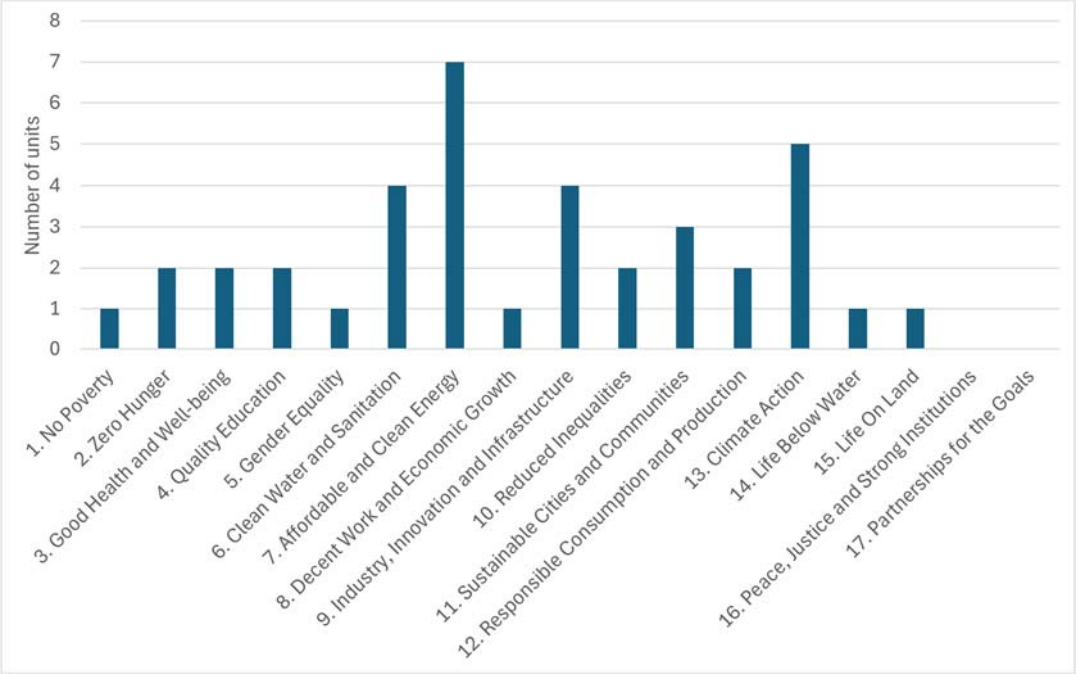

Figure 1. SDG alignment from the initial study in 2021. Individual units may map to more than one SDG.

Notably many of these SDGs identified may have related to the specific project undertaken in the year by a whole class, or to individual honours research topics which had strong alignment to particular SDGs.

2024 Data and results

To assess the UC identified alignment of units with SDGs, the publicly available information on the course and unit handbook was utilized. Of the 60 units offered across four specialisations of the Bachelor of Engineering (Hons) degree, 8 were excluded from the analysis. That is because these are new units as part of a course update which were progressing through approvals processes during the time when the SDG data was being collected university wide on existing units. A further three units received new codes and minor modifications as part of the course update process, however SDG information was available for the previous version of the unit and has been utilized in this analysis. An additional one unit is being replaced by 2 units through the course update process, so the SDG alignment is retained for only one of these new units in this analysis. Of the remaining 52 units, 28 did not include unit coordinator identified SDG alignment, including 2 which we have identified in the 2021 study as having SDG alignment – Conceptual Design and Communication and Honours Project A. As mentioned previously a course redesign

process and change of staffing occurred for the Conceptual Design and Communication unit which may have led to the SDG alignment of the current unit not being captured in the university wide data collection stage. For the Honours unit (included in the analysis), alignment with SDGs would extensively depend on the project undertaken by the student, so it may not be possible at a unit level to claim all potentially relevant SDGs. The identified SDG alignment is shown in Figure 2.

From our original analysis, three units were discontinued or replaced, and some new inclusions were made.

These new inclusions were:

- Year 1 Design unit – inclusion of lecture about sustainability, guest lecture about green bridges, EA code of ethics
- Year 1 Dynamics unit – sustainability included in the design lectures, specific to a goal

Notably the design units originally in our analysis were either removed or redefined, often leading to a reduction in the alignment with the SDGs.

The most commonly identified SDG for alignment in engineering units was SDG9. Industry, Innovation and Infrastructure which occurred in 20 units (the specific alignment with specialisations is presented on the next Figure). Following this was SDG7. Affordable and Clean Energy with 9 units. Both of these alignments are fairly reasonable, and would probably be similar in other Engineering degrees, as they are very clearly linked to the merit of engineering, as a field of knowledge. Due to the size and remote location, in our school we offer only a few specialisations (civil, mechanical and two types of electrical). This fact could potentially explain a lack of links to other SDGs (i.e. SGD 2 Zero Hunger, SDG 3 Good health and well-being, SDG 14 Life below water or SDG 15 Life on Land), which would commonly be observed when other specialisations, like chemical, environmental or biomedical engineering are offered.

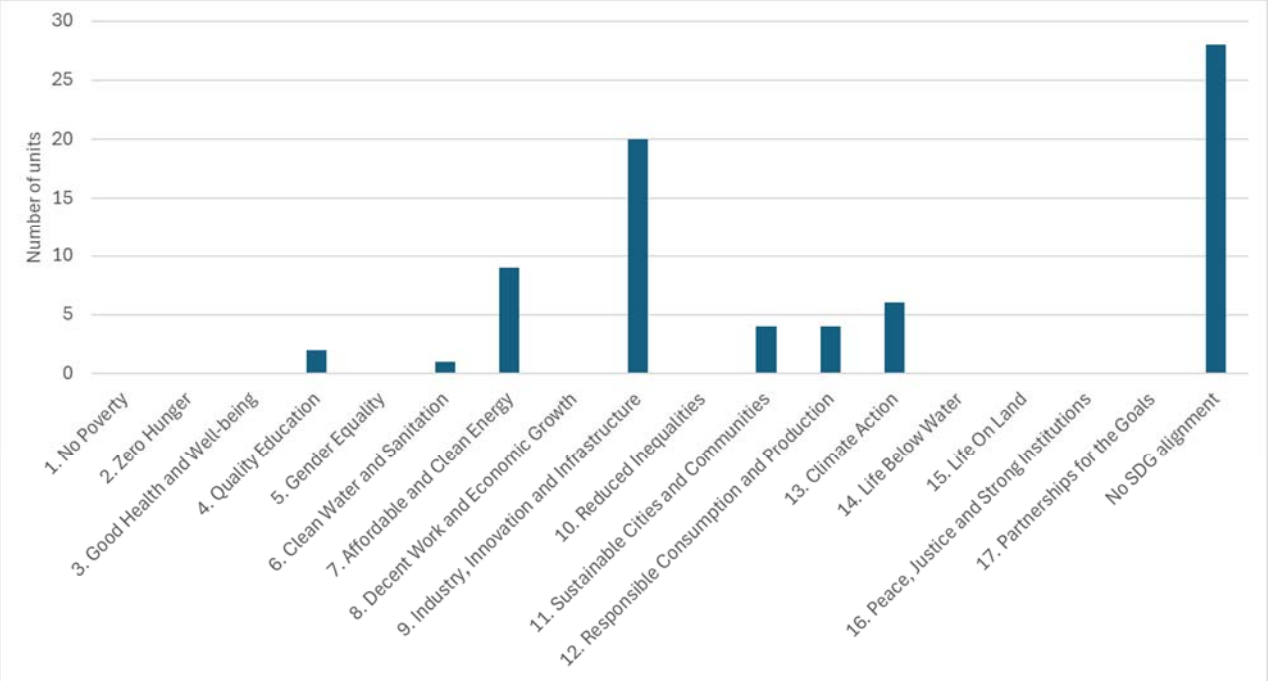

Figure 2: SDG alignment from the data collected in 2024 based on Unit coordinator identified SDG alignment. Individual units may map to more than one SDG.

Considering the data collected based on specialisation and what units are core or common demonstrates that for civil engineering related subjects SDG9 – Industry, Innovation and Infrastructure is most common, and for Electrical Power SDG7 Affordable and clean energy is most common. Mechanical Engineering units also strongly aligned with SDG9 – Industry, Innovation and Infrastructure (Figure 3). A substantial number of core and common units had no SDG alignment suggesting that this area has potential to embed SDGs to have the greatest reach across the student cohort.

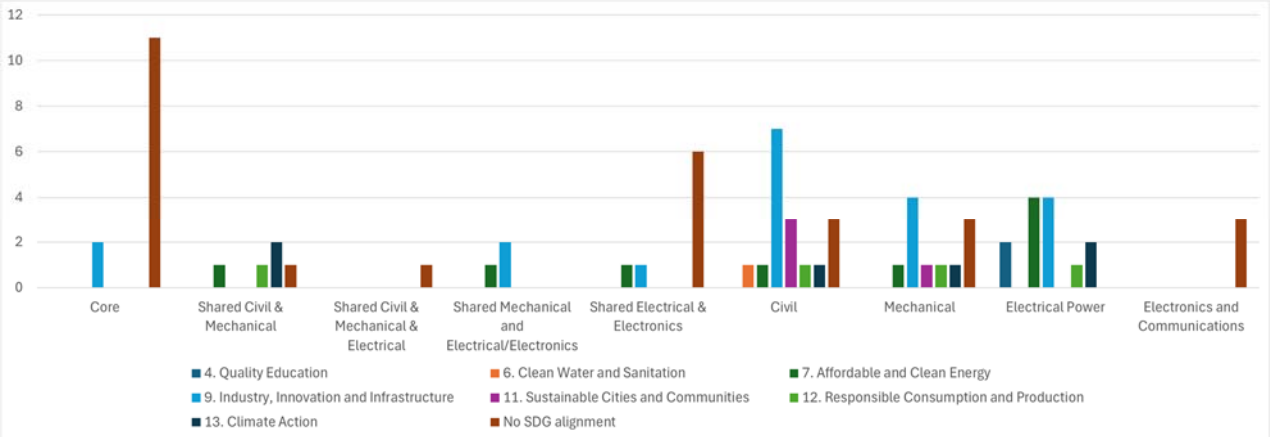

Figure 3: SDG alignment from the data collected in 2024 based on Unit coordinator identified SDG alignment, separated by specialisation and core/common groupings. Individual units may map to more than one SDG.

Figure 4 compares our original study in 2021 in terms of identification of SDG alignment across the degree to the UC identified alignment from the 2024 study. This clearly shows that a wider range of SDGs were identified as having alignment within our earlier study, and that the UC-based study resulted in a narrow band of SDG alignment being claimed, but over a wider number of units. While this might be related to the fact that some units were discontinued, and we can definitely identify two units that contained a strong alignment to specific SDG (and are not offered anymore), this discrepancy might also be related to staff being more reluctant to claim sustainability alignment in person-to-person communication (2021 data collection) rather than in a university-wide survey (2024 data). That effect could be related to a phenomenon observed by other researchers, related to the fact that teaching staff might not be confident in teaching sustainability, as they lack knowledge and experience to do so (Petrovic et al. 2017, Rieckmann 2017).

There are however in both cases, significant gaps in widespread coverage of SDGs within the engineering curricula, suggesting there is still opportunity to further improve.

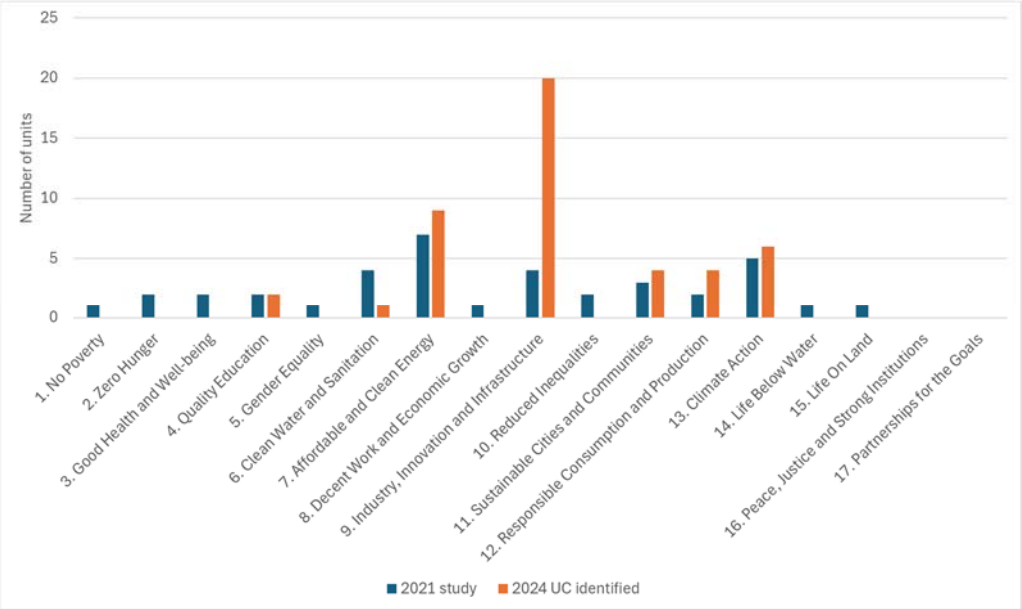

Figure 4: Comparison of the 2021 and 2024 results for SDGs alignment in the offered units

Limitations of our analysis

A different study approach was utilised in 2021 and 2024 to perform the data collection, but in both cases UCs were involved either through consideration of their unit outline and personal communication (2021) or through the university wide study (2024) As identified, some units were not captured during the university wide SDG alignment process as they were being redefined or were new units approved through a course update process. Based on these eight units were excluded units from our 2024 analysis. Our 2021 study interrogated units in more depth including considering individual honours topics and their alignment to SDGs. While this led to a wider spread of SDGs being captured across the degree, the number of SDGs which students themselves directly engaged with would be fewer.

Conclusions

While we cannot define with full confidence the reason for differences in 2021 data and 2024 data, it is obvious that sustainability and alignment to SDGs is only reported in some of the units, offered in the degree and there is some significant room for improvement. While many barriers have been identified by researchers in this space, including institutional inertia (Barth et al. 2013), resistance to change (Gale et al. 2015) or an obvious gap between knowing and being able to implement (Curran, 2020), the main enabler for more effective sustainability implementation has been named as effective collaboration between institutions (Weiss et al. 2021). We trust that by exchanging the experience between different engineering schools, we not only share experience, but also learn from each other how to make the implementation of sustainability in the engineering degree more authentic and widespread and the process smother for everyone involved. The major practical implication of this short study is that we increase awareness about the lack of authentic sustainability embedding in the degree and embark on a journey of seeking pathways to include sustainability in a more effective way. This would be significantly enhanced if supported by attention from higher management.

References

Barth, M. (2013), “Many Roads Lead to Sustainability: A Process-Oriented Analysis of Change in Higher Education”, *International Journal of Sustainability in Higher Education*, 14, 160-175. https://doi.org/10.1108/14676371311312879

Curran, G. M. (2020), “Implementation science made too simple: a teaching tool. *Implementation Science Communication* 1, 27. https://doi.org/10.1186/s43058-020-00001-z

Engineering for One Planet (2024), available from : About EOP – Engineering For One Planet, (accessed 9 October 2024)

Engineers Australia (2021). STAGE 1 COMPETENCY STANDARD FOR PROFESSIONAL ENGINEER, available from: https://www.engineersaustralia.org.au/sites/default/files/2019-11/Stage1_Competency_Standards.pdf (accessed 17 November, 2021)

Engineers Australia (2019) Code of Ethics and Guidelines on Professional Conduct, available from: https://www.engineersaustralia.org.au/sites/default/files/resource-files/2020-02/828145%20Code%20of%20Ethics%202020%20D.pdf (accessed 17 November, 2021)

Gale, F., Davison, A., Wood, G., Williams, S., & Towle, N. (2015), “Four Impediments to Embedding Education for Sustainability in Higher Education”, *Australian Journal of Environmental Education*, 31, 248-263.

Menon S. and Suresh M. (2022) “Modelling the enablers of sustainability in higher education institutions”, *Journal of Modelling in Management*, 17, 2

Quresh A. S. and Nawab A., “The Role Of Engineers In Sustainable Development,” presented at the Symposium on Role of Engineers in Economic Development and Policy Formulation, 2016. Accessed: May 15, 2021. [Online]. Available: https://pecongress.org.pk/images/upload/books/10-311%20Role%20of%20Sustainable%20Dr.pdf

Petrovic, D., McCormick, K., & Van de Bor, V. (2017), “Teaching and learning sustainability: An assessment of the integration of sustainability principles in engineering curricula”, Journal of Cleaner Production, 168, 1522-1538. doi: 10.1016/j.jclepro.2017.09.112

Rieckmann, M. (2017), “Shaping the Sustainable University of the Future: How to ‘Bend the Curve”, Journal of Sustainability Education, 12(1). Retrieved from https://www.susted.com/wordpress/content/shaping-the-sustainable-university-of-the-future-how-to-bend-the-curve_2017_12_01/

World Federation of Engineering Organisations (2021) http://www.wfeo.org/about-us/ (accessed 17 November 2021)

Weiss, M., Barth, M., Wiek, A., & von Wehrden, H. (2021), “Drivers and Barriers of Implementing Sustainability Curricula in Higher Education--Assumptions and Evidence”, *Higher Education Studies*, 11(2), 42-64. doi: 10.5539/hes.v11n2p42

Wrobel-Tobiszewska, A., Beasy, K., Fiedler, T., Mann, A., Morrison, B., Towle, N., Wood, G., Doyle, R., Peterson, C., Bettiol, S., “Common experiences and critical reflections: embedding education for sustainability in higher education curricula across disciplines”, International Journal of Sustainability in Higher Education (in review)

Wrobel, A., Lyden, S. (2022) Sustainability in the Bachelor of Engineering with Honours Degree, in K. Beasy, C. Smith and J. Watson (Ed) Education and the UN Sustainable Development Goals (pp. 375-390), Springer, UNESCO, 2023

Sterling S, Maxey L, Luna H. (2013), “The Sustainable University: Progress and prospects”, London and New York: Earthscan/Routledge.

University of Tasmania (2024), Course Handbook: Bachelor of Engineering (Specialisation) with Honours, retrieved on 1/08/2024 from https://www.utas.edu.au/courses/cse/courses/p4d-bachelor-of-engineering-specialisation-with-honours?year=2024

Copyright statement

Copyright © Anna Wrobel and Sarah Lyden, 2024. The authors assign to the Australasian Association for Engineering Education (AAEE) and educational non-profit institutions a non-exclusive licence to use this document for personal use and in courses of instruction provided that the article is used in full, and this copyright statement is reproduced. The authors also grant a non-exclusive

licence to AAEE to publish this document in full on the World Wide Web (prime sites and mirrors), on Memory Sticks, and in printed form within the AAEE 2024 proceedings. Any other usage is prohibited without the express permission of the authors.