Creating A Collaborative Benchmarking Community

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CONTEXT
Two Australian universities, ANU and UTS, are developing new compulsory core subjects for professionally accredited engineering programs across multiple disciplines. These depart from traditional siloed subjects to take a whole of program approach to the development of a range of traditional and emerging professional practice skills. The programs integrate students' technical knowledge with professional practice skills in authentic contexts using interactive pedagogy. Benchmarking is essential for new programs to understand how they may be delivering what is required. Graduate attribute and learning outcome benchmarking is an accreditation requirement from Engineers Australia and explicitly required by the Australian Tertiary Education Quality Standards Agency. However, there is scope to extend benchmarking to include teaching approaches and practices, providing an opportunity to share insights within and between universities. This aligns with the Australian Council of Engineering Deans (ACED) Engineering Futures 2035 (ACED, 2021) recommendations to “share good practice and build alliances”.

GOAL
This paper provides a case study of an ongoing collaborative approach to program-level benchmarking across two institutions delivering accredited undergraduate engineering programs. This is significant given the embedded emphasis on areas including sustainability, ethics, and Indigenous knowledge and perspectives, aligning with activities in Phase 1 of the ACED 2035 implementation project (ACED, 2023) for “benchmarking and monitoring” with “an initial focus on benchmarking human/social centred curriculum activities”.

APPROACH
Staff from the institutions began informal discussions to share their experiences. This has developed into a collaborative benchmarking activity for the new programs. Benchmarking explores program design, teaching approaches, practices and student feedback with a focus on the professional practice skills being developed across the whole four years of study (for example systems approaches, critical thinking, ethics). Benchmarking incorporates multiple perspectives including academic coordinators, professional support staff, and external domain or topic experts.

OUTCOMES
The case study highlights an alternative approach to benchmarking across programs and identifies the factors that have led to successful collaborative benchmarking. Limitations and challenges are also highlighted along with the approaches taken to minimise these.

CONCLUSIONS
The collaborative benchmarking is valuable for the participants themselves, and for future accreditation. The emerging and collaborative nature is particularly suited to programs with relatively novel teaching approaches and curriculum. In sharing this approach, it is hoped that the process can be formalised, improved and expanded on across programs and universities.

KEYWORDS
Benchmarking, curriculum change, social-technical perspectives

Introduction

The Australian National University (ANU) and the University Technology Sydney (UTS) recently independently developed new compulsory core subjects for engineering undergraduates across multiple discipline programs. At each university, the outgoing subjects had existed for some time, and had strayed from their original (presumably coherent) design as successive subject coordinators and conveners re-interpreted and revised the content, teaching approaches, and assessment. This led to a lack of clarity for students, a poorer student experience, and disjointed program structures (Blackmore et al., 2019). Simultaneously, calls for greater inclusion of human and social dimensions and systems thinking in engineering were made by national groups (ACED, 2021) and institutional commitments (such as university level graduate attributes) introduced or revised. This led to major curriculum redevelopment projects at both institutions across suites of compulsory courses. Some of the common aims of these projects were to improve the overall student experience, revise pedagogical approaches, and develop key graduate outcomes required by contemporary engineering practice and institutional graduate attributes. Both projects had the support of the relevant engineering program leadership. This support included time to research, design, and develop the new suite of subjects, a focus on student development over multiple year levels, and a staged rollout of new subjects over an incoming cohort (delivering the new courses over three to four years, not all in the same year). The new subjects at ANU have had two cohorts of graduates, with UTS to have graduates from the new sub-program in 2026. (*Note on terminology: the institutions involved use different terms for the elements of a degree program. One uses 'subject' for the discrete entity in which a student enrols, the other 'course'; subject will be used here but subject and course can be used interchangeably with a student enrolled full-time undertaking four subjects (courses) per semester at each university. A program refers to the degree the student is enrolled in, with sub-program referring to a defined sequence of subjects/courses such as a major, minor, or compulsory sequence.*)

Both institutions integrate human and social dimensions into the curriculum across the whole of the program (via a sequence of subjects), rather than a single early-stage subject (as is often the case in engineering curricula) or in stand-alone elective subjects. This covers interwoven social and technical elements of engineering including concepts like ethics, contextual understanding, and sustainability. This is critical given the embedded emphasis and scaffolded development required for these skills and concepts. The suites of subjects use an interactive pedagogy where students are exposed to authentic, complex contexts for which they need to draw on their technical skills and develop their human and socio-technical professional practice skills. The alignment of our goals in developing similar student learning outcomes with our core programs has provided an opportunity to share knowledge and experience, and to benchmark against each other. This aligns with priorities and activities in Phase 1 of the Australian Council of Engineering Deans' (ACED) 2035 implementation project (ACED, 2023) for "benchmarking and monitoring" with "an initial focus on benchmarking human/social centred curriculum activities".

This paper provides a case study of the collaborative approach to benchmarking taken at a program level across our two institutions delivering professionally accredited undergraduate engineering degrees. The paper next provides background incorporating a literature review focused on benchmarking within Australian engineering education and our institutional contexts. This is followed by the approach developed and used for continuous collaborative benchmarking. Findings on the benchmarking are presented including factors contributing to the process, general outcomes, and specific examples in a common area. Finally, a discussion reflects on the approach and its benefits and limitations, followed by conclusions and future work and research.

The sharing of information and benchmarking of the curriculum is aimed at improving the courses at both institutions. This is accomplished through understanding and discussing approaches to common issues experienced by both teams. In addition, free discussions allow the identification of curriculum gaps and the discovery of different methods of presenting sensitive topics such as the Indigenous engineering experience.

Background

Literature Review

Benchmarking is commonly employed in Australian engineering education due to processes surrounding tertiary (Tertiary Education Quality and Standards Agency, 2019) and disciplinary based accreditation (Engineers Australia, 2019). Benchmarking is typically used to compare curriculum against a set standard, often called curriculum mapping. In Australian engineering education, this is commonly the Engineers Australia Stage 1 Competencies for the Professional Engineer (Corocco, Wan & Halupka 2023, Halupka et al., 2018). Alternatively, benchmarking can be done between institutions to compare and contrast a theme of interest, for example integrated engineering subjects (Lowe & Goldfinch 2021), creativity (Valentine 2019, Valentine et al., 2019) or critical thinking (Pearson et al., 2019). Benchmarking is commonly undertaken by individual institutions using publicly available artifacts like learning outcomes, curriculum and assessment outlines from subject descriptions (Lowe & Goldfinch, 2021, Pearson et al., 2019, Valentine, 2019, Valentine et al., 2019). Methods of analysis typically include content analysis and computational text mining. These methods are extractive and limited to the information declared in public sources. They do not delve into the why, how or where things may be included as hidden or non-assessed curriculum (Rossouw & Frick, 2023).

From a regulatory perspective, benchmarking against a standard is useful to assess whether there is sufficient coverage of required competencies in the curriculum, the expected volume of learning, and required outcomes met. From an institutional perspective, benchmarking both to a standard and other institutions is a useful tool to support programmatic design decisions and continuous improvement in education design and delivery. Benchmarking is particularly helpful when making program changes to curriculum or introducing new competencies, knowledge or skills. For example, the ACED 2035 project called for mapping to support the inclusion of human and social dimensions in the engineering curriculum as a critical area for contemporary and future engineering practice (ACED, 2021). This was undertaken as part of the Engineering Futures Initiative using text mining methods analysing the intended learning outcomes (Engineering Futures Initiative, 2024). While these results show where and what socio-technical content is present in the intended learning outcomes they do not give the full story. This approach hides where concepts are practiced but do not form part of the intended learning outcomes, nor does it explain how and why the curriculum is designed as it is. Therefore, it gives insights into the facts but not depth, in a similar way to what quantitative data offers us in comparison to qualitative data. To the extent of the authors' knowledge, works have not reported a collaborative effort, diving beyond this static approach to curriculum mapping to a more qualitative discussion of the what, why, or how. This additional detail helps create an understanding of what sits behind the end product allowing for greater collaboration and reciprocation between institutions. In this way, more holistic benchmarking can support curriculum renewal for new and complex curriculum and intended outcomes at a program or sub-program level.

Institutional Context

The authors work on the compulsory, core engineering subjects in their respective engineering programs. Both programs are interdisciplinary and aim to develop socio-technical dimensions of engineering graduates including professional and transferable skills. The suite of core subjects are required for all discipline degrees or majors and seek to ensure graduates meet all of EA's stage 1 competencies and are prepared for contemporary and near-future engineering practice, including positively contributing to achieving the United Nations sustainable development goals.

At UTS the program includes five, multidisciplinary subjects from first to final year engineering. This includes a first-year subject focused on the EWB Challenge, a second-year project appraisal subject including sustainability, critical thinking, management and ethics, and later year courses on professional communication and complexity in engineering practice further developing these learning outcomes. This suite of subjects helps deliver the institutional graduate attributes focused on Indigenous Australians as well as those related to design, collaboration, communication and reflexive, lifelong learning in engineering practice.

At ANU the program forms the spine of the undergraduate degree with six subjects from first to final year. The program, known as the core, teaches a systems engineering approach in a transdisciplinary context using project based learning. A redesign of the second to final year curriculum was undertaken in 2018-2019, with the delivery of the redesigned second year subjects commencing in 2020 (see Blackmore et al., 2019 and Simmons et al., 2022 for details of the design and delivery of this suite of subjects). As part of a university-wide implementation, ANU is currently embedding an institutional set of three graduate attributes. These are critical thinking, Indigenous perspectives, and transdisciplinary problem solving. Given socio-technical and systems engineering were embedded into the core as part of the engineering program curriculum redevelopment, they are also the focus for the new graduate attributes, to be in place from 2025. Knowing these new elements were to be embedded made the benchmarking more critical and contemporary.

Approach

The approach to benchmarking that is being used between the two institutions for their core subjects has evolved from informal conversations into a continuous collaborative discussion based initiative. Informal discussions between engineering education staff at UTS and ANU identified shared interests in professional practice, transferable skills and socio-technical development. Staff were involved with the design, delivery, and evaluation of sequences of subjects designed to deliver knowledge and outcomes on these at our respective institutions. As both programs focus on social-technical aspects of engineering (such as ethics and sustainability), along with the professional skills (such as critical thinking, teamwork, and communication), these became natural areas for discussion and benchmarking. Socio-technical skills and knowledge have been highlighted as critical for engineering (and other fields) in the 21st century (ACED, 2021). While there are multiple understandings of this term, elements within it include human and social dimensions of engineering, as well as areas of sustainability such as the environmental, economic, and social domains. A further socio-technical skill discussed in this category was systems thinking.

These common interests and responsibilities led to establishing regular meetings to share our experiences. What started as informal conversations between the first four authors evolved into more organised and systematic benchmarking of our programs and curriculum renewal. In turn this grew to involve further stakeholders in the engineering core from our two institutions, as well as invited ‘critical friends’ and/or experts in content and pedagogy from our networks. A typical monthly meeting would have a short agenda with a couple of key discussion points, such as ‘critical thinking’ and ‘curriculum mapping’. Each university would take a few minutes to present on how that point is addressed in their own core, and then the conversation would evolve as similarities and differences were identified. Action points were included following up on specific aspects of curriculum and assessment (e.g. sharing a rubric on how critical thinking is assessed), or inviting a particular speaker to join the next meeting. Discussions and actions were minuted in a shared online document.

Findings

The benchmarking exercise has allowed us to move beyond factors that are normally assessed in accreditation and benchmarking. Findings related to the contributing factors for the benchmarking approach and its outcomes are presented below followed by specific examples of impacts at the two institutions.

Facilitating factors

The in-depth discussions of our programs has allowed us to look into "how" we teach and assess, and "why" we do this. Key factors that have facilitated this include: the participants' personal interests in engineering education and their commitment to developing the socio-technical skills in our graduates; the different contexts in which we operate exposing many of the enabling and inhibiting factors in delivering such programs; and benefits such as shared resources and collegial relationships. The evolution of benchmarking collaboration from informal discussions at an engineering education conference emphasises the role that participants' personal interests and experience has played in this particular case. It may be that establishing and building these collaborative activities requires self-selection rather than a top-down role-based approach to benchmarking as often used for accreditation purposes. The relative novelty of benchmarking socio-technical aspects of a program, rather than more well-established technical content, was a key motivator for the engagement. That is not to say it cannot be replicated, rather that the driver for a successful continuous process may require leadership and commitment from those involved in the design and delivery of the programs.

Of note is that, while some participants' roles have changed over the course of this process, the collaboration has continued. Contributing to this is the benefits that accrue from sharing and learning from others who are experiencing similar circumstances in their own context. Subject design and delivery is often siloed, and those teaching may not have the full view of their own programs, let alone those of other institutions. This sharing has been inspiring and beneficial to the participants. However, this contingency on participants introduces limitations. We are talking to those with similar interests and goals which risks discussions that do not challenge existing views or encourage us to consider alternatives. Being conscious of this bias could facilitate the design of more diverse teams in collaborative benchmarking exercises, such as the recruitment of "critical friends" from contexts different to our own.

Particularly beneficial to the discussions, and to some degree forcing us to evaluate our own experience more critically, has been the difference in our contexts. Unlike a more traditional benchmarking activity used for accreditation, we have not sought out contexts that match exactly. The areas of commonality include a recently designed socio-technical centred sub-program. Aside from this, the universities have significantly different sized cohorts, different organisational and degree structures, and institutional approaches to how teaching is prioritised. We are also at different stages of the rollout of the new programs. These differences have enabled us to compare and map out next steps for our own programs. For example, ANU is ahead on the rollout of subjects and has graduates, while UTS is ahead on defining the graduate attributes for the degrees. This look at "how" we design, assess and implement our teaching, dives deeper into what our programs deliver than the standard benchmarking against individual subjects.

Institutional Impacts

Further looking at the "how" we teach and assess, the benchmarking has delivered tangible benefits to the programs. As an example, one specific area is related to critical thinking which was a key outcome across both institutions. From the benchmarking completed, improvements and alterations have been identified for each program.

UTS incorporates critical thinking as a topic, teaching students how to apply critical thinking within engineering effectively. Students are exposed to various frameworks, including the Paul-Elder framework and the CRAP test. Students employ the concepts to diverse examples in subsequent weeks. Following the discussion with the ANU team and obtaining their feedback, the UTS team recognised that it would be more impactful for students to apply the critical thinking concept to several scenarios rather than teaching it within a single week. The previous method resulted in students requiring assistance to establish the correlation between the concepts and the remaining content. Furthermore, frameworks will gradually fade from memory. Hence, it is more beneficial if the instructional staff incorporated the concept of critical thinking weekly throughout the duration of the semester.

ANU has been inspired by UTS to add the concept of macro and micro ethics into the initial introduction of ethics in engineering. Ethics and the Engineering Australia code of conduct are introduced within the foundational first year course, using case studies that have had significant impacts on society. Students are also asked to consider how ethics applies to them as a learner, for example relating to academic integrity or group work. While these initial case studies provide the groundwork for more complex studies in future subjects, introducing specific frameworks such as done at UTS will provide approaches students can revisit and expand on in ethics in future core courses, as well as other subjects which consider and incorporate ethical dimensions.

In addition, UTS have taken on board the approach used at ANU for tutor development and selection. This approach sees tutors managed at the sub-program level, enabling more strategic allocation of tutors to subjects as well as the development of potential tutors over multiple years by exposure to new experiences and increased responsibilities. This approach has had numerous benefits at ANU including continued engagement with recent graduates in tutoring. This allows them to bring in relevant and contemporary professional practice. As an overall outcome for UTS, seeing a completed redevelopment (even if at a scale with a smaller number of students) has provided additional encouragement and a morale boost. Sharing stories with colleagues internally and another institution has provided a broader support network, tips and suggestions for potential barriers, and a sense of the end-goal and its impacts.

Similarly, the approach has been an excellent mechanism for ANU to reflect on the complete rollout of their new subjects as part of a continuous improvement process and be exposed to new material and ideas. Significant benefit has come from focusing on embedding the institutional graduate attribute related to Indigenous perspectives where UTS has longer experience.

Discussions

A clear benefit from the benchmarking has been the deep focus on curriculum, pedagogy, learning approaches and outcomes across a suite of subjects. This allows explorations of the how, what, and why of development. Such sub-programs are increasingly critical to embed and demonstrate attainment of skills and knowledge related to both professional engineering practice and institutional graduate attributes. Many of these outcomes cannot be achieved effectively within single subjects and hence the need, and associated benefit, from involving multiple staff at each institution. The collaborative discussions allow much greater depth to be considered than can be achieved through desktop or template-based benchmarking. Publicly available information on subjects and programs do not capture elements of the hidden curriculum which includes dimensions of organisational and individual convener values and attitudes (Rossouw & Frick, 2023). The discussion-based approach and specifically including staff involved with the design and delivery of subjects allows this hidden curriculum to emerge. This is critical when the curriculum includes a focus on socio-technical dimensions (Polmear et al., 2019).

However, this focus on the individuals involved does bring in limitations. It is obviously contingent on those involved committing their time on an ongoing basis. This can be challenging particularly during teaching semesters and when roles and responsibilities change. We have found monthly discussions have been appropriate to ensure continuity without overloading staff with recurring meetings. Further, the staff involved in subjects and sub-programs such as these often share similar values, beliefs and views. Benchmarking across such a group can lead to simply reinforcing existing approaches, and even elements of the hidden curriculum. Inviting experts for specific topics or conversations is one way to minimise this, as is the documentation and submission of this paper for external peer-review. Linking the focus of the benchmarking to larger institutional work (e.g. graduate attributes at ANU) necessitates broader conversations at our respective universities. This is where ideas or approaches raised must be justified and accepted. In this way, the benchmarking group becomes a safe space for critique, self-reflection, and brainstorming alongside work at our own institutions.

An outcome of our experience is the emergence of a benchmarking process that can contribute to the Engineering Futures Initiative (EFI) (2024). This can contribute to deeper insight into currently available benchmarking data being collected. The EFI has begun to drive program level benchmarking for degrees in Australia. As part of this, a program to review all the subject level learning outcomes across a program has been undertaken (Engineering Futures Initiative, 2024). The analysis highlights strengths and weaknesses in the degrees across Australia. However, this high-level analysis looking at learning outcomes has the scope to be augmented with more qualitative data. For example, an understanding of how the learning outcomes are taught and assessed in classrooms, and why there remains significant gaps in some of the socio-technical aspects of engineering (such as sustainability, ethics and values).

Conclusions and Further work

Introducing or redeveloping a collection of subjects or sub-programs take large amounts of energy and commitment. Coming together to share these journeys in more depth, while recognising they never really finish, has provided inspiration and support to continue with these efforts. The approach to continuous collaborative discussion-based benchmarking outlined here goes beyond the what and where into the how and why of our curriculum and institutional contexts, resources, and constraints, while recognising it potentially requires greater ongoing commitment from staff. Comparing and contrasting across two different contexts and stages of journeys has been beneficial, and drawn on the strengths of each.

By focusing on discussion, more emphasis is placed on quantitative benchmarking, which is often absent from desktop or template-based benchmarking. This moves beyond a focus on unit values, number of hours committed, or assessment weightings. This raises questions on the ecosystems of benchmarking and the value of multi-tool approaches. Value comes in diving deeply into concepts meaning that we have a much better view of what happens in other institutions; this is more effort but much more valuable than a tick box exercise.

Inline with a focus on continuous collaborative benchmarking, there are further work and plans. This may include qualitative benchmarking now the curriculum is better understood, recognising this detail is necessary for program and subject amendment processes. Potential alignment or relevance to the Engineering Futures Initiative will be explored in addition to relevance for other networks such as groups including the Australian Technology Network (ATN), Group of Eight plus (Go8+), ACED and Australian Association of Engineering Education (AAEE) to expand benchmarking. Research on learning, knowledge, and outcomes achieved by graduates is necessarily critical to ensure the curriculum delivered is effective for greater development of socio-technical dimensions in engineering. Exploring this across two different contexts will generate greater outcomes and relevance for other institutions.

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