

## Executive summary

The study considers the global state of the art in engineering undergraduate education. It was undertaken to inform Massachusetts Institute of Technology's (MIT) *New Engineering Education Transformation* (NEET), an initiative charged with developing and delivering a world-leading program of undergraduate engineering education at the university.

The study was structured in two phases, both of which used one-to-one interviews as the primary evidence gathering tool:

- Phase 1** conducted between September and November 2016, Phase 1 provided a snapshot of the cutting edge of global engineering education and a horizon scan of how the state of the art is likely to develop in the future. The analysis drew on interviews with 50 global thought leaders in engineering education and identified the most highly-regarded current and emerging university leaders in the field.
- Phase 2** conducted between March and November 2017, Phase 2 involved case studies of four selected institutions identified during Phase 1 as being 'emerging leaders' in engineering education: Singapore University of Technology and Design (Singapore), University College London (UK), Charles Sturt University (Australia) and TU Delft (Netherlands).

Together, the two phases of the study are informed by interviews with 178 individuals with in-depth knowledge and experience of world-leading engineering programs. As such, they paint a rich and diverse picture of the state of the art in engineering education as well as the opportunities and constraints facing the sector.

The report addresses five key questions, the first four of which are outlined below:

- 1. Which institutions are considered to be the 'current leaders' in engineering education?** Olin College of Engineering and MIT were both cited by the majority of thought leaders consulted in Phase 1 to be the 'current leaders' in engineering education. Other highly-rated universities including Stanford University, Aalborg University and TU Delft. Many interviewees noted that the engineering education sector was entering a period of rapid change, and they therefore anticipated considerable movement in global leadership in the coming years.
- 2. Which institutions are considered to be 'emerging leaders' in engineering education?** A number of institutions – including Singapore University of Technology and Design, Olin College of Engineering, University College London, the Pontifical Catholic University of Chile and Iron Range Engineering – were consistently cited by Phase 1 thought leaders as global 'emerging leaders' in engineering education.
- 3. What features distinguish the 'current leaders' and 'emerging leaders' in engineering education?** Institutions identified as 'current leaders' in engineering education tended to be well-established US and European research-led universities catering to large student cohorts. Good educational

practices highlighted at these institutions included user-centered design, technology-driven entrepreneurship, active project-based learning and a focus on rigor in the engineering ‘fundamentals’.

The group of ‘emerging leaders’ represented a new generation of engineering programs, many of which were developed from a blank slate or the product of systemic educational reform, and which were often shaped by specific regional needs and constraints. Distinctive educational features of the ‘emerging leaders’ include work-based learning, multidisciplinary programs and a dual emphasis on engineering design and student self-reflection. Case study evaluations suggest that the ‘emerging leader’ programs have benefitted from strong and visionary academic leadership, a faculty culture of educational innovation and new tools that support educational exploration and student assessment.

#### **4. *What key challenges are likely to constrain the progress of engineering education in the future?***

A range of barriers that continue to constrain positive change in engineering education worldwide was identified. These include aligning government and higher education goals, the challenge of delivering student-centered active learning to large student cohorts, the siloed monodisciplinary structure of many engineering schools, and faculty appointment and promotion systems that are not perceived as rewarding teaching achievement.

The final question addressed by the study was ***‘What is the future direction for the engineering education sector?’*** Drawing on evidence from both phases of work, a horizon scanning approach was used to anticipate both the future trajectory of the engineering education sector and the profile of the leading engineering programs in the decades to come. It pointed to three defining trends.

The **first anticipated trend** is a tilting of the global axis of engineering education leadership. Evidence from the study pointed to a shift in the center of gravity of the world’s leading engineering programs from north to south and from high-income countries to the emerging economic ‘powerhouses’ in Asia and South America. Many among this new generation of world leaders will be propelled by strategic government investment in engineering education as an incubator for the technology-based entrepreneurial talent that will drive national economic growth.

The **second anticipated trend** is a move towards socially-relevant and outward-facing engineering curricula. Such curricula emphasize student choice, multidisciplinary learning and societal impact, coupled with a breadth of student experience outside the classroom, outside traditional engineering disciplines and across the world. While many of these educational features appear within engineering programs at the ‘current leader’ institutions, they are often *“bolt-on activities”* and are isolated within the curriculum. As a result, much of the benefit of these experiences remains unexploited because they are unconnected with other curricular components and students are not encouraged to reflect upon and apply what they have learned in other areas of the degree program. In contrast to the ‘current leaders’, many institutions identified as ‘emerging leaders’ in engineering education typically deliver distinctive, student-centered curricular experiences within an integrated and unified educational approach. In most cases, their curricula were designed from a blank slate or were the result of a recent systemic reform. Experiences such as work-based learning and societally-relevant design projects are

embedded into the programs in a way that provides a solid platform for student self-reflection and a pathway for students to both contextualize and apply the knowledge and skills they have gained elsewhere in the curriculum. However, many of these ‘emerging leader’ exemplars – such as at Olin College of Engineering and Iron Range Engineering – cater to relatively small cohort sizes. The key innovations that are likely to define the next chapter for engineering education are the mechanisms by which such features can be integrated across the curriculum at scale: delivered to large student cohorts under constrained budgets. In the words of one thought leader:

*“The next phase in the evolution of engineering education is for the rest of us to figure out how we can offer this type of quality of education at scale.”*

The **third anticipated trend** for the sector is therefore the emergence of a new generation of leaders in engineering education that delivers integrated student-centered curricula at scale. The case studies considered in Phase 2 point to a number of institutions that have developed such a model, where this curricular coherence and integration is delivered through a connective spine of design projects. For example, the Singapore University of Technology and Design curriculum is delivered through multidisciplinary design projects, which contextualize and integrate learning across courses and years of study. A second example is the UCL Engineering curriculum which structures the first two years of study in five-week cycles, where students spend four weeks acquiring a range of knowledge and skills that they subsequently contextualize and apply in a one-week intensive design project. Interviewees also suggested that, in the longer term, some of the world’s leading engineering programs would increasingly deliver student-centered learning to large student cohorts through a blend of off-campus personalized online learning and on-campus hands-on experiential learning:

*“This is the future of the field, where you put the student at the center and use the resources to facilitate team projects and authentic experiences, and then put the taught curriculum online.”*

A number of institutions are already moving forward with such an educational model. Most notable is one of the case study institutions, CSU Engineering in Australia. This newly-established five-and-a-half-year program combines an 18-month on-campus education, framed around a series of project-based challenges, with four years of off-campus, work-based learning. Almost all ‘technical engineering content’ – including both knowledge and skills – is delivered online and accessed independently by students, as and when they need it. This program was described as “*completely rethinking what engineering education ought to look like*” with the potential to be “*very influential, if they can pull it off.*”

Taken together, the study feedback suggested that the engineering education sector is entering a period of rapid and fundamental change, where the world’s most highly-rated programs would no longer be confined to global research leaders and small boutique programs. This sets the scene for the emergence of new players from all corners of the globe that will set the future benchmark for excellence in engineering education.