Engineering Education Review

EDITORIAL

Engineering education in the intelligent age: From knowledge transfer to capacity building

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Global engineering education stands at a new historical juncture. Rapid progress in artificial intelligence, big data, advanced manufacturing, and green energy is reshaping the knowledge base, organizational forms, and value logic of engineering practice. At the same time, climate change, energy transition, public health, and infrastructure resilience have become more interconnected and harder to solve. The second United Nations Educational, Scientific and Cultural Organization (UNESCO) Engineering Report, released in 2021, argued that engineering is foundational to achieving the Sustainable Development Goals, and that engineering education and capacity building must evolve together with this expanded mandate (UNESCO, 2021). This editorial reflects on what that evolution should look like.

FROM DISCIPLINARY TRAINING TO A FOUR-DIMENSIONAL PRACTICE

It is worth distinguishing between what is commonly called "engineering disciplinary education" and "engineering education" in the fuller sense. The former denotes specialized instruction organized around disciplinary categories, aimed chiefly at building students' domain knowledge and technical skill. The latter is broader and more systemic, extending beyond disciplinary knowledge to encompass a wider range of professional capabilities (Crawley *et al.*, 2014). I would argue that engineering education today must integrate four indispensable dimensions.

Engineering science is the foundation: it addresses why phenomena occur and what principles govern them. Engineering technology translates those principles into practice, supplying the methods and tools that convert scientific understanding into productive capability. Engineering management concerns the organization of large-scale collective effort—resource allocation, process coordination, and team coordination—that turns technical vision into built reality, as seen in aerospace programs or major infrastructure projects. Engineering culture, finally, is the value and constraint layer: it engages questions of sustainability, ethics, and social responsibility, asking for whom engineering is done and whether it serves human welfare. A curriculum that trains only the first two dimensions produces competent technicians; one that integrates all four produces engineers capable of exercising judgment in a complex world.

A SHIFT TOWARD COMPLEX PROBLEM-SOLVING

Across countries, the stated goal of engineering talent cultivation is shifting from knowledge mastery toward the capacity to solve complex, ill-structured problems (Graham, 2018). This shift is visible in the growing emphasis on interdisciplinary integration—linking engineering with computing, life sciences, materials, environmental studies, management, and the humanities and social sciences. Many of today's engineering problems are no longer confined to a single traditional discipline; they are systemic, intertwining technology, industry, society, and environment. As engineering is increasingly recognized as a driver of sustainable development and a means of addressing shared global challenges, the demand for international cooperation in engineering education continues to rise.

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CHINA'S POSITION: FROM SCALE TO STRENGTH

China has moved steadily from being a country with a large volume of engineering education to one building genuine strength in the field. Its system is large in scale, comprehensive in structure, and strongly practice-oriented. Reform of curricula, the establishment of professional accreditation systems, and the promotion of innovation and entrepreneurship education have all advanced, alongside deeper participation in international mutual recognition frameworks such as the Washington Accord (International Engineering Alliance, n.d.). At the same time, Chinese engineering education retains a distinctive strength: its close integration with national modernization, industrial upgrading, and major engineering projects gives it rich application scenarios, strong organizational capacity, and a deep base of practical experience. The task ahead is not only to expand and strengthen this system further, but to gain a stronger voice in the international discourse on engineering education and a greater role in shaping its rules.

TSINGHUA'S APPROACH: REAL PROBLEMS, INSTITUTIONAL NORMS

Tsinghua University's ongoing reforms—advancing "Engineering Plus," interdisciplinary integration, and pedagogical innovation—offer one useful reference point. Two aspects seem particularly noteworthy. First is an emphasis on real-world problem orientation: bringing scientific principles and technical tools to bear on genuinely complex problems rather than confining their use to surface-level applications. Second is the parallel effort to build institutional norms that govern the relationship between new technology and educational values, so that adoption of powerful tools does not outpace the safeguards needed to use them responsibly. These reforms carry implications well beyond one university, offering a model for how engineering programs elsewhere might reconcile innovation with responsibility.

WHAT THE INTELLIGENT AGE ASKS OF YOUNG ENGINEERS

Lifelong learning is no longer optional for engineers; it is a professional necessity. In my view, the excellent engineer of the intelligent age needs at least five things: a solid engineering foundation, systemic thinking, the capacity to collaborate effectively with intelligent machines, ethical awareness and social responsibility, and a global outlook coupled with the ability to communicate and collaborate across boundaries. These capabilities build on longstanding calls for engineers to combine strong technical foundations with communication, ethical responsibility, leadership, and a global outlook (National Academy of Engineering, 2004). No single institution can cultivate this profile alone. Universities must reconstruct curricula and pedagogy around real problems and interdisciplinary practice; enterprises must supply authentic problems and practice environments beyond the classroom; and government and society must build the institutional environment and public support that sustain this work over time.

TOWARD A CHINESE CONTRIBUTION TO GLOBAL ENGINEERING EDUCATION

I hope China can move from being a follower of international standards to a co-formulator of them. The contribution of Chinese engineering education need not be measured only by the number of capable engineers it produces. It can also lie in offering the world an engineering education model rooted in Chinese practice—one addressing shared problems of sustainability, scale, and responsible innovation that no single country can resolve alone. That, ultimately, is the transition this editorial has tried to describe: from knowledge transfer to capacity building, and from a national project to a shared global one.

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