

More Rethinking of Chemical Engineering Education

Part 1: Content and Constraints of the Education System

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In a recent article in *Nature Chemical Engineering*,^[1] chemical engineering scholars provided six accounts of how each would reimagine the curriculum. These authors rightly point to several emerging content areas for chemical engineering. They also touch on aspects of the education system itself and some research-based pedagogical practices. In a series of two editorials, we add to that conversation, elaborating on these issues. In this first editorial, we discuss content and, importantly, how content decisions are intimately tied to the constraints of the education system. In the second, we expand notions of content arguing for the need to explicitly attend to students' development of engineering practices within discipline-specific topics. Taken together, these address how students form into chemical engineers through our teaching which, obviously, is of great importance to chemical engineering educators.

We agree with the authors from the *Nature Chemical Engineering* article that machine learning and generative artificial intelligence (AI) have vast potential to aid in the work of chemical engineers, and that students should learn this content. As educators, however, we should also be cognizant of their emerging disciplinary dispositions. Some students may first encounter AI as a convenient way to quickly circumvent the intent of instruction. We need to help students transition to see AI as a tool for deeper disciplinary thinking. Additionally, we agree with the authors' identification of two additional frontiers (beyond biology) of renewable energy and materials design/management. Here, materials design/management, especially corrosion, may have been understated. This topic has been appearing more frequently at AIChE Annual Meetings. As large, expensive infrastructure assets age, chemical engineers will need to continue to both design new materials and manage existing materials, especially those in aqueous environments.

Of course, content considerations are entangled within the education systems in which we teach. Chemical engineering is a professional degree and as such BS degree programs have historically required 140+ semester credit hours. However, political and social currents to make college affordable have led to reductions to around 120 credit hours. Additionally, the Engineering Accreditation

Commission has reduced the minimum number of engineering topics for ABET accreditation to 45 credit hours (and broadened interpretations of what can be counted). As curriculum designers, we must continue to grapple with how we include this emerging content while keeping a strong disciplinary core and making it tractable for ever more diverse students to successfully learn and take up engineering identities.

Simultaneously, as educators, chemical engineering faculty have ever growing responsibilities. We are on the front line with students daily, responsible for recognizing mental health challenges, being sensitive to FERPA privacy requirements, and attending to Title IX responsibilities. We are also increasingly involved in student recruitment activities and advising undergraduate researchers. In the classroom, we must develop the pedagogical content knowledge required to understand how learning occurs and appropriately design learning activities. Taken together, *teaching* chemical engineering should be recognized for the diverse skill set required, extending far beyond content knowledge. This instructional expertise is typically not appropriately recognized for the growing class of teaching faculty, who often take on the most challenging courses such as capstone design and senior laboratory. Moreover, faculty are typically evaluated primarily by student evaluations. While the student voice is important, as a metric of quality instruction these evaluations are flawed. The rewards system at the university, through retention, tenure, and promotion, needs to be updated to better account for the importance of the teaching activity – especially using appropriate metrics of quality instructions.

The next generation of educators must be technically current, but also receive professional development that focuses strongly on how they engage with students, both for learning and inclusion. We discuss this point in the second part of this editorial in the Fall issue.

REFERENCES

1. Gong J, Shallcross DC, Jiao Y, Venkatasubramanian V, Davis R, and Arges CG (2024) Rethinking chemical engineering education. *Nature Chemical Engineering*. 1(2):127-133. DOI: <https://doi.org/10.1038/s44286-024-00029-1> □