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COMMENTARY

From Slide Rules to AI: Reflections on the Evolution of Chemical Engineering Tools

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Abstract

Chemical engineering, like other engineering disciplines, has evolved from manual calculations to advanced process simulators and artificial intelligence tools. This perspective piece reflects on how such technological shifts have transformed both professional practice and engineering education. Drawing from historical perspectives and current teaching experiences, it examines the balance between leveraging modern tools and fostering deep conceptual understanding. The discussion invites educators to critically assess how and when to integrate digital resources into the chemical engineering curriculum.

Keywords: chemical engineering, education, technology.

Chemical engineering focuses on the improvement and scaling-up of chemical processes at industrial scale. These processes range from fluid transport and heat transfer phenomena to operations involving direct contact between substances, such as mixing, reaction, and separation. Scaling-up requires the application of mass and energy conservation laws, as well as the design of equipment for these operations. While these are core topics in chemical engineering, there are also complementary areas such as process control, petrochemistry, electrochemistry, engineering economics, safety and environmental management, among others. The theoretical foundation of chemical engineering is, of course, directly related to sciences such as chemistry, physics, and mathematics. In recent years, biology and data science (applied statistics) have become increasingly relevant, driven by the complex demands of the industrial sector for process optimization and environmental regulations [1, 2].

To trace the origins of chemical engineering as a discipline, we must go back to the late 19th century, where George E. Davis (1850-1906), known as the father of chemical engineering, delivered a series of lectures at the Manchester Technical School in which he introduced key chemical engineering concepts. In addition, he attempted to establish the first professional organization for practitioners in the field and published the influential manual "A Handbook of Chemical Engineering" [3, 4]. In 1888, Professor Lewis M. Norton launched the first four-year chemical engineering program. In the early

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20th century, William H. Walker in collaboration with Arthur D. Little introduced the concept of unit operations and later, in 1923, together with William H. McAdams, they published “Principles of Chemical Engineering” [5]. In 1907, the Massachusetts Institute of Technology (MIT), became the first university to offer a doctoral program in the discipline. Other major milestones in chemical engineering include the publication of the textbooks "Perry’s Chemical Engineering Handbook" and "Transport Phenomena" [6, 7]. From its origins to the present days, chemical engineering has been closely linked to thermodynamics, mathematical modeling, and technological tools. The use of thermodynamic tables, property diagrams, and manual calculations has been essential for equipment design and process scale-up. Therefore, the evolution of the tools used by chemical engineers, whether slide rules or modern simulation platforms, has always been fundamental to the practice and teaching of the discipline.

In informal conversations with my professors, I often heard stories about how chemical engineering was taught when they were students. One of the aspects that most caught my attention was the use of slide rules, essential tools for complex calculations long before the advent of calculators. They also shared how technical drawings were done entirely manual, requiring not only precision but also artistic skill, something later replaced by Computer-Aided Design (CAD) software. There was even a course dedicated to graphical analysis, in which students learned to interpret and construct diagrams manually. Solving lengthy integrals by hand was also the norm, rather than the exception, and required a deep understanding of mathematical procedures that today could be assisted, or circumvented, by symbolic calculation tools.

During my early years as a chemical engineering student, many teaching practices still reflected a transitional phase between traditional and digital methods. For example, equilibrium charts were drawn by hand on graph paper, and although some of the younger professors had begun to introducing tools like Microsoft Excel, it was still considered a novelty, rather than a standard practice. Manual calculations were the basis for most assignments, including the solution of extended integrals, especially in reactor design courses. At the time, the use of symbolic or numerical computation tools was limited, and many of us were unaware of how essential they would soon become. Regarding programming, I recall learning the classic "Hello, world!" example, without fully understanding the transformative role that computational thinking and coding would eventually play in areas such as numerical methods, process modeling, and optimization. It wasn’t until more advance courses that we were introduced to various specialized software programs such as Aspen Plus, MATLAB, Maple, and Mathematica, primarily to facilitate problem-solving in separation processes, reactor design, or process control. This gradual incorporation of digital tools marked the beginning of a paradigm shift (from manual rigor to computational efficiency) that reshaped the way chemical engineering problems were approached in both academia and industry.

Regarding Computational Fluid Dynamics (CFD) software, I initially questioned its introduction in the early stages of the program (usually the fourth or fifth semester). Many students still lack the mathematical maturity or numerical training necessary to set up and interpret these models meaningfully. After completing a general numerical methods course, are they truly prepared to tackle the complexity of discretized fluid transport equations? Another question arose: Do students need to master numerical methods to use CFD effectively? Perhaps this is simply another generational transition, like using Excel instead of graph paper, CAD software instead of manual drawings, or calculators instead of slide rules. The essence of engineering remains the same, but the tools continue to evolve. A similar dilemma is now emerging with the rise of artificial intelligence in chemical engineering education. AI tools can solve partial differential equations or optimize process units with minimal human intervention. But this brings us to a fundamental question: are we improving students’ understanding or are we ignoring the development of essential engineering thinking?

As professors, our responsibility is not merely to teach tools, but to cultivate engineering judgment. We must ask ourselves: Do these modern tools empower students or do they foster dependency? Perhaps, as with previous generations, the key does not lie in which tool is used, but rather in how and when it is integrated to support rigorous conceptual understanding.

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Conflicts of Interest

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Ethical Approval and Consent to Participate

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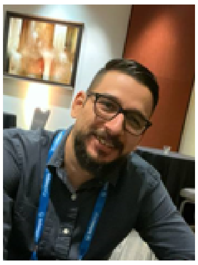

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