STEM 2040 – Beyond the Industrial Paradigm

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2020: Exposing the cracks in the undergraduate structure

Today, college is often assumed to be 4 years long, occurring between the ages of 18 and 22, spent on lush campuses where young people follow a prescribed curriculum, attend social events, and root for incredibly expensive college sports teams. STEM education is geared to mostly male graduates of heavily white middle-class high schools: the culture can be chilly or outright hostile to women and non-whites. To compensate for lack of interest by domestic students in STEM fields, universities have come to rely on international students who pay higher-than-native tuition for undergraduate degrees; then in many cases staff labs as PhD and postdoctoral students.

Colleges and universities are engaged in a prestige race focused more on student amenities than on career outcomes or social good. The cost of new dorms and recreational facilities, subsidies to athletics, and heavy student-services programming has driven annual tuition increases that outpace inflation for more than 35 years. Student loan debt stands at more than $1.6 trillion dollars and constitutes a major drag on the larger economy.

The system is cracking. In the midst of Covid-19, fraternity living and/or social events are widely banned, college football has already been cancelled in two conferences, and many students are taking gap years rather than pay full tuition for online instruction. Black Lives Matter and related social movements such as #MeToo challenge higher education to be inclusive in meaningful ways.

For a variety of reasons, many institutions are finding life without Chinese and Indian STEM students to be financially challenging. Zoom and other video technologies have proven that many "impossible" remote interactions -- medical visits, PhD defenses, worship services, and classroom instruction -- can in fact work just fine via a camera and screen.

Imaging the future of STEM

Let us assume that undergraduate STEM education in 2040 will have 30% of its students following a model similar to today’s. What will the other 70% look like? A pessimist would assume that university enrollment would plunge; an optimist would see that 3 times the population can be educated using new, scalable models while university resident enrollment remains stable.

College is no longer only 4 years long, nor must it begin at high school graduation. Different lifestyles, family structures, career trajectories, personal commitments (possibly to a voluntary form of national service), and financial realities will lead to proliferating forms of "college."

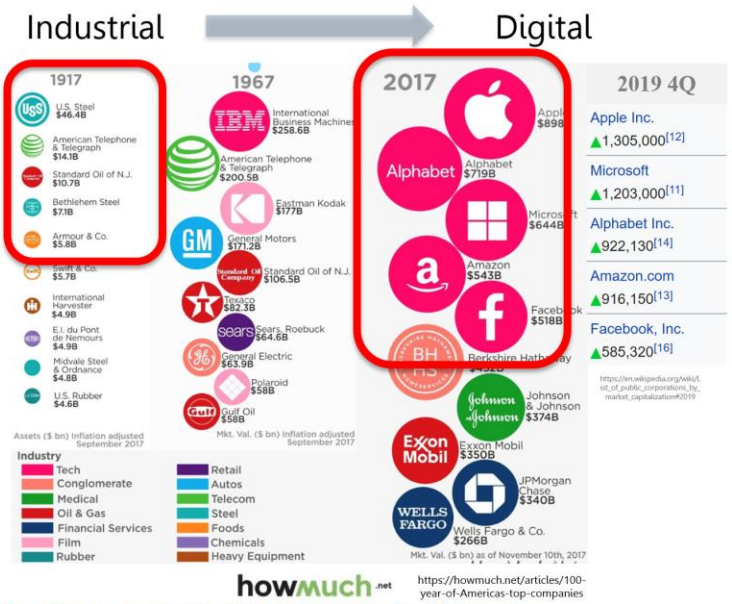
Maybe a student takes 4 years, working 30 hours/week, to complete an associate's degree, then she gets a co-op that leads to a scholarship from her employer for the final 2 years of a BS/MS in a technical field. Or consider new options for educating military veterans, many of whom require disability accommodation. Or consider new models of workforce retraining that redefine both career resets and undergraduate credentials.

Undergraduate STEM education needs to become more culturally welcoming and flexible. In part, this will involve integrating new models of the undergraduate credential as noted above. It may also involve a reinvention of the HBCU, the online training and education provided by Lynda/LinkedIn/YouTube/EdX etc, and community outreach to attract more diverse students to STE(A)M fields at a younger age.

Today the US is highly dependent on Chinese and Indian a) brains and b) tuition dollars. In part, technologies like no-code programming environments such as Salesforce Lightning and Google AppSheet will broaden the pool of available technical talent. It is to be hoped that better pre-K to 12 educational practices will further broaden and deepen that pool. Finally, a new model of undergraduate STEM education can be reinvigorated to be more inclusive, more relevant, and -- in plain English -- less boring and more closely connected to the invigorating work of live problem-solving.

Enabling the transformation of STEM education

Today we live in a global digital economy; supply-side economies of scale (such as plants or real estate) confer fewer advantages than they did 50 years ago. In the figure, the top 5 companies today measured by market cap are all technology platform companies. Built on demand-side economies of scale, they leverage user contributions to offer a variety of services at unprecedented scale.



https://howmuch.net/articles/100-years-of-americas-top-10-companies
https://en.wikipedia.org/wiki/List_of_public_corporations_by_market_capitalization#2019

For STEM 2040 we need to transcend the factory model of the industrial era and design new educational platforms in the Google/Amazon vein by working across and beyond universities. We can leverage professional societies such as AIChE or ASME, government agencies such as NASA and NIST, and other organizations to connect across boundaries. This will enable educators to pull in and curate resources from a wide range of sources such as Khan Academy, LinkedIn Learning, YouTube, and LearnChemE. A shared public/private/university

digital platform can improve accessibility by supporting more modes of learning (including simulations), heighten relevance and create social value by working live problems, reach students on their choice of devices, improve job placement and satisfaction, strengthen the nation's economic competitiveness through workforce enrichment, and in general bring to STE(A)M education the same attributes that enable Google and Amazon to cost-effectively and instantly satisfy massive customer bases with highly personalized content.

Outcomes of an integrated digital platform for 2040 STEM

- Higher throughput: more students can access STE(A)M education at much lower cost
- Better scientific and technical literacy, reversing a painful decline in basic understanding of and respect for science
- Support for 21st-century science and technical pedagogy
- Broader STEM application in society/economy: address shortage of US-born programming and data analytics talent in many fields
- Economic equity: STE(A)M fields tend to pay well, and opening these jobs to traditionally underrepresented groups spreads the wealth into more communities
- Improved innovation: increasing the diversity of the STE(A)M workforce will bring in new perspectives, understandings, and team dynamics
- More relevant and more-easily shared knowledge will a) accelerate and deepen learning, b) enable innovation, c) support life-long learning, and d) illuminate new pathways of career development.