**Discussion of Biasi, Deming, and Moser "Education and Innovation"**

Eleanor Wiske Dillon[1]
Microsoft Research New England

Many conditions must come together for someone to develop a successful innovation. She, or he, must understand the current base on knowledge in her area in order to build on it; she must have the spark of a new idea; and she must have the inclination and security to take a risk in developing her idea. Both the content and the structure of educational institutions can be designed to foster these conditions.

In this chapter, the authors focus largely on the role of education in providing for the first condition: a base of knowledge from which to innovate. In particular, they emphasize that incomplete and unequal access to quality education leaves some potential entrepreneurs without the base of knowledge they need to develop new ideas. Providing this base of knowledge is undoubtedly the most important role of education in supporting innovation. Failure to provide quality education to all young people will lead to missed opportunities and lower the overall pace of innovation in the economy. In education systems like that of the United States, where access to education varies systematically with parents' income and with race, this failure also reinforces existing inequalities by shutting down a path for economic mobility.

Democratizing access to general education, while valuable for many reasons, is a broad policy and may have limited direct effects on the rates of invention. I will focus my discussion on whether the existing economic literature can suggest more targeted interventions that would particularly spark innovation. I follow the authors on focusing mainly on the U.S. context. Universities with strong track records of producing successful innovators share a focus on building mentor relationships, exposing students to real-world open questions, and training in STEM (Science, Technology, Engineering, and Math) fields. Providing curricula with these themes in high school, which nearly all young people now complete in the U.S., could be another powerful policy for increasing both the representativeness and total level of innovative entrepreneurship.

**Access to Training for Innovation**

Attendees of a small set of U.S. colleges account for an outsized share of U.S. patents (Bell et al., 2019). Not all innovations generate patents, and not all patents are innovative, but this tight concentration of patenting suggests some colleges and universities are creating environments that nurture invention, beyond simply catching students up to the frontier of knowledge. Biasi, Deming, and Moser emphasize that these most innovative colleges are often small and private (Cal Tech and MIT top the rankings by rates of patenting[2]) and admit relatively few low-income students. Increasing access to these colleges could create more equitable opportunities and reduce the strong relationship between parental income and future innovation in the United States.

[1] eldillon@microsoft.com. Thanks to the organizers Aaron Chatterji, Josh Lerner, Scott Stern, and Michael J. Andrews and the chapter authors Barbara Biasi, David Deming, and Petra Moser.

[2] As part of a larger project using Census data, Bell et al. match U.S. citizens born between 1980 and 1984 to the college they attended for the longest time and also to U.S. patent records. They then report the share of attendees matched to each college who hold at least one patent.

However, these current centers of innovation make up a tiny fraction of college seats in the United States. Democratizing access to these schools will do little to increase overall innovation unless capacity is simultaneously increased without affecting the quality of instruction. In Bell et al.'s sample, the 10 colleges with the highest rates of patenting among their students produce 90 patent holders per 1,000 attendees, in contrast to 7 per 1,000 in the remaining sample. These 10 colleges had a combined enrollment of just over 30,000 undergraduate students in 2018—about the same size as Purdue University.[3]

Policymakers and educators could do more to spur innovation by bringing successful elements of entrepreneurial instruction into more colleges and high schools, reaching a wider audience. Pinpointing what these institutions to do promote invention is difficult in observational data, and I have not found any economic studies that attempt it, but profiles of programs like Stanford (Read, 2019) and Technion (Solomon, 2019) suggest a few common practices. Both programs put students in contact with successful entrepreneurs, creating mentorship opportunities. Both also set students to work on current open problems suggested by businesses through class projects and hackathons. Finally, both programs place a specific emphasis on training in STEM fields.

**Ingredients of Education for Innovation**

Each of these ingredients in training for innovation has at least suggestive support in existing economic studies of innovation and entrepreneurship. Bell et al. (2019) find that young people who grow up in a neighborhood with more inventors are more likely to later become inventors themselves, and more likely to innovate in the same fields represented by inventors in their early neighborhood. Girls are more likely to go on to innovate in the same fields as female inventors in their neighborhoods, but not more likely to follow in the fields of local male inventors. Bell at el. interpret these findings as evidence that neighbors are not just affecting general human capital accumulation (through, for example, higher quality schools), but also sharing specific knowledge and mentorship. Lerner and Malmendier (2013) find that Harvard Business School graduates who interacted with more former entrepreneurs during school were more likely to succeed if they started businesses in the future, providing further support for the importance of learning some soft skills directly from active entrepreneurs.

There is also outside evidence on the importance of exposure to open questions. Chatterji (2009) and many others document that past experience in incumbent firms in the same industry improves entrepreneurial success. While industry experience provides specific skills, helping would-be innovators reach the current frontier of knowledge, it may also surface the kinds of open questions that successful innovations can answer. Koning et al. (2020) find that female medical researchers are significantly more likely than male researchers to patent innovative treatments for female diseases and conditions, which may reflect different priorities but again reinforces that innovators must identify an open problem before they can solve it.

As the authors discuss in this chapter, several studies find persuasive evidence that increases in STEM training, such as increased vocational and technical secondary education in Italy (Bianchi and Giorcelli,

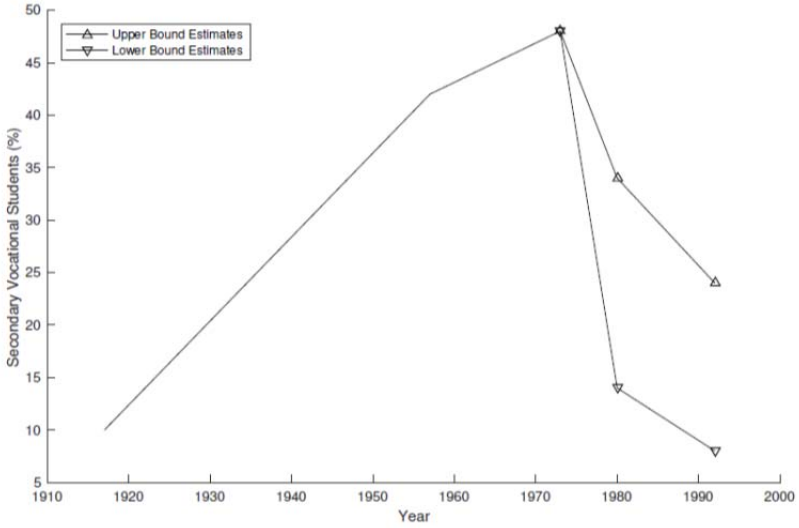
[3] Top colleges are from the data Bell et al.'s released with their paper. Counts are full-time undergraduate enrollment in Fall 2018, from the Integrated Postsecondary Education Data System.

2019) and expanded engineering training in Finland (Toivanen and Vaananen, 2016), generate increases in patenting. The current patent system is better designed to protect innovations in the sciences than in, for example, business operations. These studies may therefore partially capture a transfer of talent and energy from fields where innovations are not captured by patents to fields where they are. However, these are also fields where computerization has rapidly expanded the frontier of what is possible and created entire new fields, with well-documented increases in the demand for workers trained in these areas by incumbent firms. It is reasonable to believe that this training is also particularly valuable for entrepreneurs in this era.

**A Role for Vocational Training**

Bringing curricula that develop entrepreneurial skills to more colleges, and particularly to secondary schools, would do at least as much to capture more would-be innovators as improving equitable access to the elite, but small, institutions that already target these skills. Technical and vocational curricula, which have declined recently in the United States but remain common in many European countries, would seem to be a good environment for this training. Most U.S. high school students follow an academic curriculum, which emphasizes abstract thinking and general knowledge such as mathematics and writing in preparation for college course work. In contrast, vocational tracks teach applied and often technical skills, providing applied, subject-specific knowledge that is otherwise not available until post-secondary schooling. Increasingly, European vocational tracks emphasize apprenticeships and direct links with active businesses (Hampf and Woessmann, 2016). These kinds of curricula could provide all three ingredients for innovation: a focus on technical STEM subjects, mentorship from innovators, and exposure to open questions.

**Figure 1: Share of U.S. Secondary School Students in Vocational Tracks**




Source: Alon (2018) "Earning More by Doing Less: Human Capital Specialization and the College Wage Premium." Lower and upper bounds indicate more or less restrictive definitions of vocational curriculums.

Vocational training lost popularity in the United States partially from a perception that multiple tracks would tend to segregate low-income, non-white, and lower-performing students into applied curricula without strong earning prospects while preserving the path to affluence through academic training and

college for more privileged students. However, there is growing interest among policymakers, academics, and the public for thoughtfully designed, high-quality technical training in secondary school.[4] Renewal of these programs should include opportunities to switch tracks, commitment to high-quality training, and an awareness of the potential of these programs to reinforce inequalities rather than mitigating them.

I know of no research that estimates the effects of vocational secondary school curricula on business starts or innovation, but several papers find generally positive effects on labor market outcomes (Jacob, 2017). In one recent example, Bertrand et al. (2019) study a reform in Norway that improved that country's vocational secondary school track, including adding apprenticeships, and led to increased enrollment. They estimate that entering vocational training generates a noticeable increase in post-school earnings, particularly for men, who were more likely to choose the more technical fields of that training. One aspect of the reform allowed students to convert from a vocational track to an academic one, which enabled them to go on to college, but the earnings gains are not a result of men taking this opportunity. This result suggests that vocational training teaches skills that are separate from those learned in college, but still valuable in the labor market.

Bertrand et al. (2019) also find that enrollment in Norway's vocational secondary school track reduced criminal charges during students' teenage years, presumably because they were more occupied with school, and modestly increased secondary school completion. Creating strong vocational secondary school options appears to engage students who are otherwise on the margin of dropping out or engaging in illegal activities that would hamper future work. Potential innovators may particularly benefit from these alternative paths through secondary school. Levine and Rubinstein (2017) find that the most successful entrepreneurs have both high cognitive skills and a higher likelihood of having engaged in petty criminal behaviors (i.e. vandalism) in high school. Providing opportunities for creative thinking and applied problem solving early could generate the extra benefit of catching out-of-the-box thinkers before they drift out of the system. Exploring the potential for well-designed vocational training to increase innovation would be a valuable area for future research.

**References**

Alon, Titan (2018). "Earning More by Doing Less: Human Capital Specialization and the College Wage Premium." Unpublished.

Bell, Alex, Raj Chetty, Xavier Jaravel, Neviana Petkova, and John Van Reenen (2019). "Who Becomes an Inventor in America? The Importance of Exposure to Innovation." *Quarterly Journal of Economics*, 134(2), pp. 647-713.
Data: https://opportunityinsights.org/data/?geographic_level=0&topic=0&paper_id=520#resource-listing

Bertrand, Marianne, Magne Mogstad, Jack Mountjoy (2019). "Improving Educational Pathways to Social Mobility: Evidence from Norway's "Reform 94"." *NBER Working Paper* No. 25679.

[4] See Jacob (2017) for a survey of recent academic work, and a cry for more attention, or Belkin (2018)'s *Wall Street Journal* article for an example of public interest.

Bianchi, Nicola, and Michela Giorcelli (2019). “Scientific education and innovation: from technical diplomas to university STEM degrees.” *Journal of the European Economic Association*.

Chatterji, Aaron K. (2009). “Spawned with a Silver Spoon? Entrepreneurial Performance and Innovation in the Medical Device Industry.” *Strategic Management Journal* 30 (2): 185–206.

Hampf, Franziska and Ludger Woessmann (2016). “Vocational vs. General Education and Employment Over the Life-Cycle: New Evidence from PIAAC.”*CESifo Working Paper Series* No. 6116.

Solomon, Shoshanna (2019)**.** “Technion Fosters Entrepreneurship within Ivory Towers as Startup Nation Calls.” *Times of Israel*, December 25. https://www.timesofisrael.com/technion-fosters-entrepreneurship-within-ivory-towers-as-startup-nation-calls/

Read, Max (2019). “How to Major in Unicorn.” *New York Magazine*, September 4. https://nymag.com/intelligencer/2019/09/how-to-network-through-stanford-university.html

Belkin, Douglas (2018). “Why an Honors Student Wants to Skip College and Go to Trade School.” *Wall Street Journal*, March 5. https://www.wsj.com/articles/college-or-trade-school-its-a-tough-call-for-many-teens-1520245800

Jacob, Brian (2017): “What We Know about Career and Technical Education in High School,” Technical Report, Brookings Institution.

Koning, Rembrand, Sampsa Samila, and John-Paul Ferguson (2020). "Inventor Gender and the Direction of Invention." *AEA Papers and Proceedings*, 110: 250-54.

Lerner, Josh and Ulrike Malmendier (2013). "With a Little Help from My (Random) Friends: Success and Failure in Post-Business School Entrepreneurship." *Review of Financial Studies*. 26(10) pp. 2411–2452.

Levine, Ross and Yona Rubinstein (2017). "Smart and Illicit: Who Becomes an Entrepreneur and Do They Earn More?," *Quarterly Journal of Economics*, 132(2): 963-1018.

Toivanen, Otto and Lotta Väänänen (2016). “Education and Invention.” *Review of Economics and Statistics*, 98(2): 382–396.

U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS), 2018, Four-Year Institutions. Retrieved from https://nces.ed.gov/ipeds/ on 6/12/2020.