By Stuart Anderson

Technology Boom Helped Drive International Students to the United States

THE iPHONE IN YOUR POCKET may be a key reason for the rise in international students in United States. Of course, it's not just the iPhone that has accelerated globalization in higher education but the many changes in technology that have transformed commerce and daily life. Would international students still have come to the United States without the technological changes we've witnessed? Yes. Would their numbers have increased so dramatically? Not a chance.

Over the past 30 years, technological changes have encouraged foreign nationals to study computer science, electrical engineering, and other fields that would help to build their careers and U.S. universities have become the leading destination for these ambitious students. In the 1979–80 academic year, 283,503 international students were enrolled at U.S. universities, but by 2009–2010 that number had more than doubled to 623,119, according to the Institute of International Education.[1]

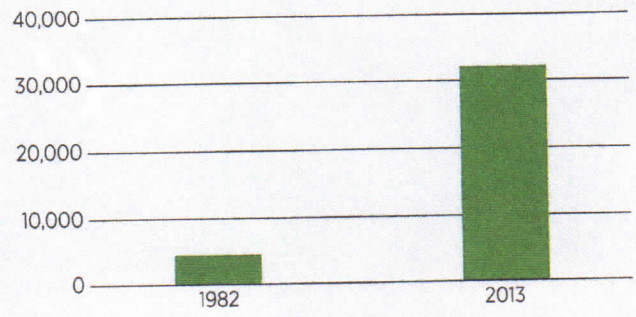
The increase in international students over that period was much greater for graduate enrollment than for undergraduates. Over the 30-year period between 1979–80 and 2009–2010 graduate enrollment increased by 199,755, or 212 percent, compared with a rise of 101,911, or 59 percent for undergraduates. Similarly, over the 20-year period between 1989–90 and 2009–2010, graduate enrollment increased by 73 percent in contrast to 48 percent for undergraduates.

The increases in graduate enrollment in technology-related fields have helped fuel the rise of international students in the United States. Between 1982 and 2013, graduate student enrollment (full- and part-time) in computer science increased by 635 percent, from 4,373 to 32,148. In electrical engineering, between 1982 and 2013, graduate enrollment increased by 386 percent, from 6,302 to 30,670.[2]

What were the technological changes that increased the demand for high-skilled labor and, as a result, also increased the interest of international studies to pursue technical degrees? As detailed below, these include the development of the Internet, smartphones, social media, portable and streaming music and video, and other advances.

FIGURE 1

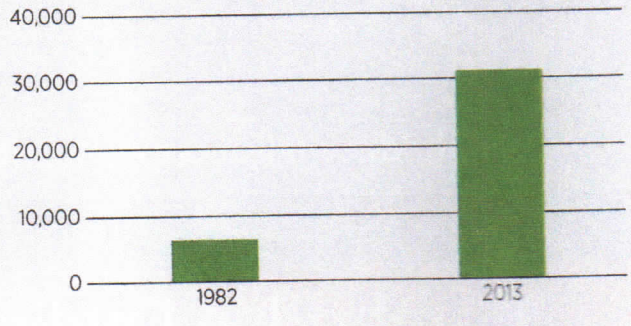
Increase in International Student Graduate Enrollment in Computer Science at U.S. Universities: 1982 to 2013



Source: National Science Foundation, Survey of Graduate Students and Postdoctorates in Science and Engineering, https://ncsesdata.nsf.gov/webcaspar/.

FIGURE 2

Increase in International Student Graduate Enrollment in Electrical Engineering at U.S. Universities: 1982 to 2013



Source: National Science Foundation, Survey of Graduate Students and Postdoctorates in Science and Engineering, https://ncsesdata.nsf.gov/webcaspar/.

TABLE 1

Technological Advances Since 1990

TECHNOLOGICAL ADVANCE	1990	2016
World Wide Web*	Did not exist	3.2 billion users worldwide, integrated into operations of all major companies.
Smartphones	Did not exist	Over 2 billion owners; have transformed entire industries.
Mobile Applications	Did not exist	Over 179 billion app downloads yearly on mobile devices.
Social Media	Did not exist	74% of U.S. Internet users visit a social media site.
Streaming Music	Did not exist	164 billion songs streamed in U.S. in 2014.
Streaming Video	Did not exist	84% of Internet traffic will be streaming video by 2018.
Gaming over the Internet	Did not exist	671 million people worldwide play online games.

Source: National Foundation for American Policy, Money, The Telegraph, Forbes, Pew Research Center, Nielsen SoundScan, Cisco, comScore.
*Software for World Wide Web not distributed widely until 1991; in 1990 World Wide Web did not exist for individuals on a global scale.

The Internet as a Commercial Force

While the Internet existed in 1990, the World Wide Web did not exist on a global scale for individuals.[3] Engineers created the Internet but it was designed for people with strong technical backgrounds, which limited its usefulness to the general public. That changed in 1991. "In the summer of 1991 Tim Berners-Lee, a computer systems analyst at CERN, released the first World Wide Web software to the high-energy physics community," according to Pamela Samuelson and Hal R. Varian of the University of California-Berkeley. "The Web put a friendly face on the Internet, providing an interface that a 10-year old, or even a 50-year old, could easily understand. Perhaps more importantly, the back-end protocols for authoring and distributing Web pages (HTML and HTTP) were easy to understand and use as well, facilitating the rapid deployment of Web servers."[4]

Worldwide, "the number of Internet users has increased from 738 million in 2000 to 3.2 billion in 2015."[5] But it took time for the Internet to develop into a commercial force, with the development of web browsers representing a key boost to Internet commerce. Marc Andreessen, who later cofounded Netscape, led the team that in 1993 released the Mosaic browser. "Mosaic's charming appearance encourages users to load their own documents onto the Net, including color photos, sound bites, video clips, and hypertext 'links' to other documents," explained *Wired* magazine. "By following the links—click, and the linked document appears—you can travel through the online world along paths of whim and intuition."[6] Within a few years, Microsoft launched Internet Explorer, marking an escalation in what became known as the "browser wars."

Smartphones

No smartphones existed in 1990. But by 2016, smartphone users were expected to exceed 2 billion, meaning one-quarter of the world's population will own one. By 2018, 2.6 billion, or about one-third of the people on Earth, will possess a smartphone.[7] And the economic impact of the smartphone is expected to grow. "Smartphones will remake entire industries, at unheard-of speed," according to *The Economist*. "Uber is a household name, operating in 55 countries, but has yet to celebrate its fifth birthday. WhatsApp was founded in 2009, and already handles 10 billion more messages a day than the SMS global text-messaging system. The phone is a platform, so startups can cheaply

create an app to test an idea—and then rapidly go global if people like it. That is why it will unleash creativity on a planetary scale."[8]

Whether the phone is produced by Apple, Samsung, or another company, it is the computing power that makes today's smartphones so different from anything conceived of decades ago. "Apple's iPhone 6 is roughly 1 million times more powerful than an IBM computer from 1975—which took up an entire room—according to a rough estimate by UC Berkeley's Bokor," reports CNet.[9]

The iPhone and other smartphones helped unleash applications or "apps." After Apple created an App Store and competitors followed suit, thousands of games and other applications flooded the marketplace, which created demand for individuals with the technical skills who could develop and support these applications.

Social Media

Today 74 percent of adults who are online use at least one social network website.[10] Social networks developed and proved popular as a way to connect with school friends and soon evolved into a way to make new friends. Classmates.com started in 1995 and SixDegrees.com, which allowed the creation of user profiles, began in 1997. In 2002 Jonathan Abrams created Friendster. In 2003 LinkedIn was founded and focused on professional networking, while Myspace aimed at nonbusiness users.[11]

In 2004 Mark Zuckerberg and his cofounders launched Facebook, which soon eclipsed Myspace to become the world's most popular social networking site. "Facebook is king for a reason. It wasn't just through luck that founder Mark Zuckerberg's darling came to reign supreme over the social media kingdom," explains Digital Trends, a website for news, information, and reviews. A key difference between Facebook and Myspace (formerly listed as MySpace) is that Facebook adopted a platform that made it possible for developers to create apps for Facebook.[12]

Twitter, founded in 2006, allows users to send out "tweets" of 140 characters or fewer and is one of the world's most visited websites, according to Alexa.[13] Twitter is often in the news when celebrities, athletes, or politicians post something considered controversial. But it is also used by performers, companies, and individuals to connect with fans and consumers.

Portable and Streaming Music and Video

In the 1950s when someone wanted portable music, he or she needed to walk around with a transistor radio. By the 1970s and 1980s, portable music came in the form of the Sony Walkman, but was limited to what could fit on a 90-minute cassette tape.

In 2001 Apple released the first iPod, which allowed portable music in the form of digital files to be downloaded onto a device. In that same year, Apple created iTunes and later the iTunes Store as a way for consumers to purchase and download audio and video files. Later, individuals could download songs and videos onto their smartphones.

Eventually, music sites developed that gave listeners the option to stream songs or pay to download them. Among the most popular of these have been Pandora, Spotify, and Rhapsody. Technological developments made these companies possible. "Before the rise of the MP3, even the most fanatical music fan, with a basement stacked high with LPs, tapes and CDs, wouldn't have had a fraction of the 20 million songs available on a child's smartphone via serves like Spotify or Rhapsody," according to Eric Brynjolfsson and Andrew McAfee, authors of *The Second Machine Age*.[14] In 2014 approximately 164 billion songs were streamed online in the United States.[15]

Video and books also became much more portable. In 2007 Amazon launched Kindle, its first eBook reader. A later version, Kindle PaperWhite, could store 2,000 books, which is more books than most people will read in a decade.[16] Other Kindle versions allow consumers to download movies and TV shows.

The first "tablet" to sell millions of copies was Apple's iPad, which was released in 2010. By April 2011 the company had sold more than 15 million units. The original iPad had a 9.7 inch screen and was portable, since it weighed less (and took up less space) than a laptop. Consumers could use it in meetings or for playing music or video. Apple came out with new versions and competitors introduced their own tablets.

Online streaming of television and movies also did not exist prior to 1990. Reed Hastings and Marc Randolph started Netflix in 1997 as a company that rented DVDs to consumers by mail for a monthly subscription. But Hastings saw online streaming of video as the future, particularly given the immediacy it provided consumers. Streaming technology allowed Netflix to produce original programming and to make hours of content available to consumers without the need for scheduled viewing time, as in traditional television. Today, Netflix has "over 70 million members in over 190 countries."[17] Netflix's competitors include Hulu (and Amazon). Cisco estimates that by 2018, 84 percent of Internet traffic will be streaming video.[18]

What about other advances? Improvements in graphics have led to an estimated 671 million people worldwide playing games online.[19] Using 3-D printers, aircraft makers can produce parts and doctors have made certain medical devices, illustrating that some key technological advances are extremely promising but still may be in their infancy.

Are All Companies Now Software Companies?

Today "software companies" is an elastic term, since even companies delivering traditional products and services rely on software, which means greater demand for people with such skills. Internet pioneer Andreessen has pointed out the oil industry, financial services, and stalwarts like Wal-Mart and FedEx utilize software for logistics and other purposes to gain an edge on competitors and satisfy customers.[20]

Andreessen also could have written about pizza. "The atmosphere at company headquarters feels more like Silicon Valley than a fast-food company," observed economist Stephen Moore during a visit to Domino's. "Most employees here are computer programmers and technicians monitoring in real

time what people are ordering, how long it is taking to fill an order, and the online complaints and comments that stream in. Their mission is to streamline the pizza-making process."[21] In short, software and technology have spread throughout the economy.

Conclusion

Major technological breakthroughs over the past 30 years have increased the demand for high-skilled labor. The changes have encouraged international students to come to the United States, where many startup companies have been leading the revolution in innovation. While innovation can destroy jobs, such as in the early 1900s automobiles replacing the horse and buggy, it can also create exciting new opportunities. For the past 30 years there has been no better place in the world to learn about opportunities created by new technology than at U.S. universities. **IE**

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[1] Institute of International Education, *Open Doors* Data. By 2014–15 the number of international students reached 854,639.

[2] National Science Foundation, Survey of Graduate Students and Postdoctorates in Science and Engineering, https://ncsesdata.nsf.gov/webcaspar/.

[3] Parts of this article were adapted from Stuart Anderson, *The World Has Changed Since 1990, U.S. Immigration Policy Has Not*, NFAP Policy Brief, National Foundation for American Policy, September 2015. Funding from the Ewing Marion Kauffman Foundation supported the research.

[4] Pamela Samuelson and Hal R. Varian, "The 'New Economy' and Information Technology Policy," University of California, Berkeley, July 18, 2001.

[5] Jacob Davidson, "Here's How Many Internet Users There Are," *Money*, May 26, 2015.

[6] Gary Wolfe, "The (Second Phase of the) Revolution Has Begun," *Wired*, October 1994.

[7] Sophie Curtis, "Quarter of the World Will Be Using Smartphones in 2016," *The Telegraph*, December 11, 2014.

[8] "Planet of the Phones," *The Economist*, February 28, 2015.

[9] Roger Cheng, "Moore's Law is the Reason Your iPhone is So Thin and Cheap," CNet, April 16, 2015.

[10] "Social Networking Fact Sheet," Pew Research Center, 2014.

[11] "The History of Social Networking," *Digital Trends*, August 5, 2014.

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[14] Eric Brynjolfsson and Andrew McAfee, *The Second Machine Age* (New York: W.W. Norton & Company, 2014), p. 109.

[15] Nielsen SoundScan, as cited in "Nielsen Music: 2014 At-A-Glance," January 2, 2015.

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[18] Carla Marshall, "By 2018, 84% of Internet Traffic Will Be Video Content," *ReelSEO*, 2015.

[19] Amarpal Singh, "Asia Pacific Has Largest Daily Online Gaming Audience," comScore, June 11, 2013.

[20] Marc Andreessen "Why Software Is Eating the World," *The Wall Street Journal*, August 20, 2011.

[21] Stephen Moore, The Weekend Interview, "How Pizza Became a Growth Stock," *The Wall Street Journal*, March 13, 2015.