

Manufacturing, Design, and Innovation

This is an expanded version of my welcoming address to the "Workshop on Building the National Network for Manufacturing Innovation," September 27, 2012, held at the western conference center of the National Academies, Irvine, California. [Website](#)

On behalf of the National Academy of Engineering, I am delighted to welcome you to the National Academies' western home and to this jointly sponsored workshop. As many of you know, the National Academies has four parts: Science, Engineering and Medicine. The fourth part is the National Research Council that does definitive, careful studies of topics of interest to the US government, the house and senate, and to the country. The engineering side has been extremely concerned with the demise of manufacturing in the US, which is why it has taken so much interest in this endeavor.

Here are two stories that illustrate the issues we face.

STORY 1: A HARDWARE STARTUP

I am on the board of a small startup company in the Chicago area. We make sophisticated multi-touch control panels for commercial use: think of it as making the colorful, easy to use gesture controls you see on smart phones, but for the commercial market. Our devices work in extreme hot and cold, in the rain, even if the workers are wearing gloves.

We manufacture in Chicago. But recently, we opened up a manufacturing facility in China. Why not expand the Chicago facility? Why go to China?

Lower cost labor? No. Labor is a minor part of the part cost. The availability of sufficiently skilled workers? No, we have no trouble finding good people in the Chicago area. Zoning or taxes? No.

We went to China for two reasons: Supply chain and financing.

Supply chain.

Our panels are components: part of larger products. Our controls are added on top of LCD display screens, and then sent to the OEM, who inserts them into their product. Where are LCDs made? China. Where are the final products manufactured? China.

Having to ship components back and forth between Chicago and China is disruptive. It adds inefficient, disruptive time delays and adds cost. It makes troubleshooting inefficient should difficulties arise. The supply chain works best when tightly-coupled parts are co-located.

Financing.

A second problem is financing. The feeling in the world of funding is that manufacturing companies are not viable. Software is hot. High margins, little capital investment. Just a bunch of young kids. Manufacturing though takes capital investment. Margins are lower. It takes longer to recoup the investment.

Take a bunch of young kids, right out of school, with some social-networking, sharing idea, and in six months they can get a few million bucks to fund their company. I'm working with two software startups who have received tens of millions of dollars of funding despite having no sales in one case and miniscule sales in the other.

Take a bunch of seasoned veterans with a physical product that requires manufacturing, such as my Chicago company, and it is very difficult to get funding. In the case of my Chicago company it took forever to get a few million from investors. This company had real sales, real customers. Some of you may even use products that use its components. My two Silicon Valley companies got four times the amount of funding in a shorter period.

We received a large order that required us to enlarge our manufacturing facilities, but we had difficulty getting the necessary funds in the United States. Our Chinese partner volunteered to build the line for us in their facilities. Why? Because we both won: they were able to increase their sales by offering a combined package of LCDs and touch control panels, which also increased our sales. Finally, we dramatically simplified supply chain issues.

I asked the CEO if he could describe the issues for me to use in this talk. I quote from his email:

Without access to capital, manufacturing endeavors are not possible. Angels and VCs are seldom interested in manufacturing related investments and banks won't look at you, unless, of course the company is well established with plenty of capital on hand. ... here in the US we have lost the appetite for or the understanding of how, manufacturing works.

... it is easier and faster to get a simple decorated cover lens (glass with silkscreen printing) from China than from here in the US. We have systematically destroyed our skills to make physical products. Even if I had all the capital to build full production in the US, I could not buy enough raw materials to keep my lines running. We setup and launched product (with our partner in China) in 2 months. It took us over 12, here in the US.

Why move to China? Because of funding and supply chain. What would it take to move back to the United States? It is an interconnected system. We must solve all the components:

1. Supply chain
2. The ring of part suppliers

3. Financing

STORY 2: MIT AND NORTHWESTERN REMOVED THE WORD "MANUFACTURING" FROM THEIR MBA/ENGINEERING PROGRAMS

Two of the top MBA programs in manufacturing in the United States were Northwestern's *Master in Management and Manufacturing* program and MIT's *Leadership for Manufacturing* program. Both were dual-degree programs, so the students received an MBA and an Engineering masters degree.

Both schools changed the names of their programs to eliminate the word "Manufacturing" from the title. Northwestern's program was renamed *MMM*, where the letters had no meaning. MIT's program was renamed *Leadership for Global Operations*.

I was co-director of the Northwestern program from the engineering side when the name was changed. I taught design to the MBA students. Why did we delete manufacturing? The students drove the change. Manufacturing was not where the excitement lay. The name was keeping good students away. Design was exciting to them, as were global operations and supply chain. Not manufacturing.

I asked my MIT colleague why LfM changed. He said:

"The students felt strongly that operations, and particularly global supply chain management, had become the issue of greatest interest for manufacturing companies."

The popular perception among young engineering and business students is that manufacturing is dull: the future is design and operations. This is a serious problem in our attempt to revive manufacturing in the United States. These young, ambitious MBA/Engineers represent the future. We have to capture the future.

WHY I AM OPTIMISTIC: STEPS TOWARD A SOLUTION

1. We Can Build on Our Core Competencies.

What is the United States good at? What are our core competencies?

- Design.
- Innovation.
- Invention.
- Ideas.
- Creativity.
- Out-of-the-box thinking.

My field is Human-Centered Design: making products that people can use, that fit their needs, that excite them and are enjoyable. The United States leads the world in human-centered design. This is true in all domains: computer and cellphone applications,

industrial equipment, work tools for professionals, and of course home and consumer electronics. It is not an accident that the entire world relies on our operating systems: Apple, Google, and Microsoft for phones; Apple and Microsoft for computers.

We lead the world in design, especially human-centered design.

2. There Is a Resurgence of Interest in Making Things.

There is also a wonderful surge of interest in building things. We see this in:

- The Do-It-Yourself (DIY) movement.
- The Makers communities.
- The birth of hardware incubators and workshops
- The great success of hardware contests in schools, from robots to electric vehicles.
- The development of additive manufacturing methods, especially the introduction of 3D printing.

Some of you may look at this list and complain that these are all small, hobbyist or simple batch-processing methods. Additive manufacturing and 3D printing, for example, are slow and limited in the types of material they can use, and the size and quality of the parts they produce. Better machines are expensive. Yes, General Electric uses 3D printing to produce components for their large jet engines, but these are not produced with the kind of numbers that modern mass manufacturing requires.

3. Disruptive Innovation Is Our Ally.

All the criticisms of the resurgence of interest in making things are true. But read Clayton Christensen's work on Disruptive Innovation: All disruptive technologies start out as toys, far too limited to be taken seriously. Want an example? Think of the home PC: those of us in the computer business scoffed at the limited capability of the Apple II and the IBM PC. We used powerful computers by DEC, Silicon Graphics, and Sun Microsystems. Every one of those companies is now dead, killed by the PC.

New technologies cause people to rethink how they do things. They enable new methods that had never before been thought about. Mass customization may finally become real. Moreover, over time, the technologies become better, more robust, of higher quality and capability, and all at lower cost.

4. We Can Build on our Competencies.

This is the beginning of a revolution in manufacturing. Let's take advantage of it. Let's drive it.

Let's build on our competencies in design and innovation. This means making them valued here, in the United States, which means encouraging engineers to want to build, make, and create. Providing the talent to manufacture here, where the ideas come from.

Supply chain issues will help us: When design, supply, and manufacture are co-located, efficiencies rise, time delays are eliminated, quality goes up.

5. The NAE Initiative in Manufacturing, Design, and Innovation (MDI).

The National Academy of Engineering (NAE) has launched a Manufacturing, Design and Innovation Initiative to focus on the transforming nature of manufacturing. Creating and delivering products and related services that have value to customers and society.

The major theme of the NAE workshop was the integration of Manufacturing, Design, and Innovation. Integration is key to success.

MANUFACTURING IS A SYSTEMS PROBLEM

This is a systems problem. We cannot bring back manufacturing to the United States with a single solution. Not new technologies, not new manufacturing methods, not better access to capital, not better suppliers, better supply chain, better political support. Not even disruptive innovation.

No single one of these will do the trick. Each is necessary, but each alone is not sufficient. We need all of them.

This is a system: we need to rebuild the entire system.

Let's build on these competencies. Which means making them valued here, in the United States, which means encouraging engineers and managers to want to build, make, and create. We need to marry manufacturing with Design and Innovation, to restore the supporting supply chain infrastructure, and to assemble the political support, the financial capital, and all the necessary parts of the system.

We need to get back the thrill of creating things, of making, building. And yes, manufacturing. We need more people who find this exciting. And to make this happen we need to change. Hence, this conference.

REFERENCES

[Advanced Manufacturing Portal:](http://manufacturing.gov)

<http://manufacturing.gov>

[NAE Report: Making Value: Integrating Manufacturing, Design, and Innovation to Thrive in the Changing Global Economy](#)

Clayton Christensen on Disruptive Innovation:

Don Norman bio

Don Norman is both a businessperson (VP at Apple, Executive at HP and an academic (Harvard, UC San Diego, Northwestern, KAIST). He is a member of the National Academy of Engineering, an IDEO fellow, and a trustee of IIT's Institute of design. As co-founder of the Nielsen Norman Group he serves on company boards and helps companies make products more enjoyable, understandable, and profitable. He is the author of "The Design of Everyday Things," "Emotional Design," and "The Design of Future Things. His latest book is "Living with Complexity. He lives at www.jnd.org.