

# Technical Competency And The Work Environment

by Dennis L Feucht

The grand enterprise of technology accommodates a wide range of skill sets, allowing individuals of widely varying abilities to participate in productive technical work. Those of us who have achieved an engineering level of competence each have a history of personal development, and none are the same. One chief engineer I know at a major electronics company started as a technician. The paths to greater competency are sometimes surprising and can be unpredictable.

At all levels each individual brings to the laboratory or field a unique skill-set. An experienced technician can often accomplish tasks that an engineer might never have tried. Yet technicians are usually not hired to do engineering and engineers are not hired to be technicians. There must be some rationale to the assessment of competence at various levels.

What are these competence levels? They have, over time, become somewhat formalized, and it might be good to reflect on this rating system, if that is what it is, and on what to make of it. Consider the following table:

Competence Level	Construction	Diagnosis & Repair	Standard Design	Novel Design	Research
Hobbyist	×				
Technician	×	×			
Technologist	×	×	some		
Engineer	×	×	×	some	
Inventor	×	×	×	×	
Scientist					×

There is an ascendancy in competency from hobbyist to engineer. The categories of inventor and scientist have been added to make differentiation of skills more explicit. A good design engineer is an inventor if doing novel design. A scientist, however, is not functionally an engineer. Scientists discover truth about physical reality while engineers apply both scientific and engineering (design) principles to solve problems. That's the simple explanation of the difference though, in practice, leading-edge engineers -- functioning as inventors -- might be led to seek out new physical principles on which to base new design methods. What distinguishes scientists and engineers at a more basic level is intent. Scientists are driven to understand the physical world while engineers are driven to apply it for human benefit.

Some engineers are not good at construction and some do not repair electronics devices well. The fully competent engineer, however, is capable across the spectrum of theory and practice. The first company I worked for was Tektronix. Engineers each had a wooden U-bench. The lengths of the sides of the U on most benches were 6 feet, but more established engineers had 8-foot benches. How the bench was used was up to the engineer. The custom, arising from functional optimization, was to use one side as a desk and the other as a laboratory. With green graph paper ("Murray pads") and calculator on one side, and test equipment on the other (with some parts cabinets in between the sides, on the connecting bench segment), theory and practice were integrated into a single environment. It took a half-second turn of one's chair to traverse between the two aspects of engineering.

The second and last company I worked for was different. This company was not founded by inventive engineers but by a lawyer. It had a large room with desks. This was the engineering department. In other rooms down the hall were laboratories. The connectedness of theory and practice in this case was weak. Having spent my formative years at Tek in an integrated environment, I did not like the new layout and its dichotomy between theory and practice. To achieve integration, I could opt for making my office space partly laboratory. The motor-drive design I was doing meant bringing a dynamometer, and other big noisy equipment, into the office area. That would probably have been viewed as being in bad taste. The other option was to do everything around my lab bench. I migrated to the lab instead.

At Tek, engineers did not usually lay out their own circuit boards but the board layout area was always close by, and the engineer usually spent much time with the layout person. As a growing engineer, I quickly came to realize that for high-performance instruments layout was not only an engineering-level task, but one of the more challenging aspects of design. It could not be handed off to a semi-skilled worker. A few board layout people at Tek, technicians by background, were so good at the intricacies of high-speed circuit layout that they could be entrusted with much of the job. But even at a competency-intensive place like Tek these highly-knowledgeable layout people were exceptional. At my second employer a mechanical engineer just out of school, with essentially no knowledge of electronics, was assigned to do board layout. It was unpleasant for me to have to deal with this different style of engineering.

I started working at Tek at age 17 and left at age 35. Consequently, I knew very little about how engineering was done in other companies. Engineers from outside who joined Tek told stories about their past work environments. One came from the aerospace industry and told of the typical engineering environment: a huge hanger filled with a matrix of desks. Engineers worked fixed hours, dressed in business suits and ties, lived under uninspiring work policies, and carried out technically-boring tasks such as interfacing boxes. The boxed subsystems were designed by people doing more interesting work. I wonder if I would be an engineer today if that had been my beginning!

Engineers who live in worlds that are conceptually distant from the world of hands-on, do-it-yourself bench experimentation, from tinkering, and from creative dream-building are not living fully as engineers. They might have been granted an engineering degree from an academically-accredited university. They might have potential, but having the degree is not the same as doing creative design work, which is the essence of engineering. We knew this instinctively at Tektronix and discussion with engineers from other leading test and measurement equipment companies, such as H-P and Fluke, seemed to confirm that there does exist an optimal engineering style and environment. This environment is populated with people having similar outlooks, attitudes about engineering, work habits, and policies supporting them. In time, I realized that not all companies have an optimal engineering environment. This tended to correlate with their suboptimal product performance and troubled projects. This in turn correlated with their absence among the companies who are technical leaders in their electronics specialty.

The principles of engineering-environment optimality have not really changed with the changes in electronics technology itself over the last 40 years. Most Tek engineers had their own home laboratories in their youth and were in this sense born engineers. They took the initiative to design and build electronic devices, spending what little money they had to advance their capabilities. Most of them were avid readers of electronics literature, mainly the three or four grocery-store-rack electronics magazines that are now out of print, or hard to find. With a strong interest in electronics their attention was not easily diverted to fast cars, girls, sports, drinking, or other distractions.

At Tek, the exemplary engineers continued in this basic mind-set, and the founders, who were like-minded, set policy accordingly. Work hours were flexible, achievement was driven by intrinsic interest in the subject-matter (you were at Tek because of your high interest), and dress (within certain wide bounds) was irrelevant. One guy came to work barefoot and in overalls. A couple of them flew their helicopters to work, and there was a landing pad near the engineering buildings. One flew his plane to work, into the Beaverton airport, within a half-mile walking distance. Eccentricity ran fairly high. Politeness did too. Lively discussion of new ideas was common and the environment carried a fairly high level of excitement about new possibilities. These were often quickly tried on the bench, sometimes at odd hours. Employee-employer trust was high and implicit. Employees could use parts from the company parts room for building projects not directly related to current work tasks. A policy was that design engineers could spend 10 % of their time on "blue sky" projects. The honor system prevailed and worked. It was as close to a real-life Tom Swift Enterprises as you could find. We were, to put it in the words of Hiro a native-Japanese engineering manager at Tek, "turned on, bubbling over".

Advancement was not based on status, such as degrees or honors, but on what you could actually do. The environment was performance-oriented. Even a janitor discovered an improvement to an instrument front-panel. If you advanced the state of the art, this implied better products and a better market position for the company. That was incidentally desirable, of course, but it was not the main motivation of upper management, at least not when Tek's founders were still running the company. They started Tek driven by technical interest, not money. The motivations of company leadership set the foundation of the engineering environment, and this manifested itself in the leading oscilloscope supplier in the world. Similar environments created by Bill Hewlett and David Packard, and by John Fluke, led to similar results in their respective instrument companies.

Because these companies have historically been technology-driven and not money-driven, they excelled at technology and consequently earned money. It has taken decades for competitive oscilloscope manufacturers to close the technical-excellence gap with Tektronix. This suggests that the optimal engineering environment is not able to be created by business management merely by willing it into existence with sufficient money. To some extent leading engineers can be bought off, but they are not enough. Usually, they are not allowed to set the environment, which business management often likes to keep under its control, misguided by the notion that it is simply part of running a business. Often, the critical importance of the technical environment is not even known. Engineers, from this typical business viewpoint, are labor commodities, like unskilled workers. Rarely is the fragility of a productive engineering environment realized, nor the time and difficulty attending its creation.

Finally, these tech-driven companies tend to be small and are often started by inventive people who are stymied as employees at the larger, more sedentary companies. They leave with a good idea in mind, develop a product in their home laboratory, and start growing. Other creative people, attracted to the ambience of the lively start-up, become caught up in the motivation of the founder and a concentration of high competency and productivity commences. Eventually the enterprise becomes wildly successful, and all kinds of auxiliary and support people join. Organization competes with innovation, the business world takes notice, and the Establishment moves in for the kill, buying out the enterprise from the founders, only to stock it with "bean counters," draining it of its remaining vitality, running it into the ground and putting it on the chopping block on Wall Street.

Depleted of metaphors, my one recommendation to entrepreneurs with growing companies is to spin off business units as new companies which form a federated network and share capital-

intensive resources. Each spin-off remains small, focused, and energetic and, hopefully, retains the youthful vigor of a small, growing enterprise.

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