Considered a leading entrepreneur in nanotechnology and a devoted educator, Virgil Elings taught at UCSB as a professor of physics for more than 20 years. In 1987, he co-founded Digital Instruments Inc. in Santa Barbara, together with UCSB alumnus Gus Gurley, bringing the first commercially-available scanning probe microscopes to market. These microscopes, which include the Atomic Force Microscope and the Scanning Tunneling Microscope, are used in microscopy and manipulation at the nanometer scale. Elings served as president and chairman of Digital Instruments until 1998, when the firm merged with Veeco Instruments, Inc.

Elings received a doctorate in physics from MIT and holds more than 40 patents. He is known for his innovation and business acumen, his local and national philanthropy, and his love of motorcycles. He recently talked with Convergence about education, his own teaching career and the role of the university in preparing students for life after graduation.
Q: Research universities tend to teach a more theoretical approach to engineering. What do you think is the right mix of theory and project learning?

Elings: It involves the question of what should be learned. There's a big difference between teaching and learning. What counts is whether the students learn anything. The way school operates, we're all treated the same. We all get the same test. But there's a better way to learn — project learning. You give people, in a group or individually, a problem to solve, something to make. And it turns out that making something work amounts to much more than getting 80% on a test. The skill these students learn is how to function given their unique talents.

But you must have been attracted to theory; you got a PhD in physics.

I was brainwashed by the system. Everyone who has a PhD is brainwashed. They tell you the educators are the smartest guys you'll ever see. But you aren't what you eat. You aren't the sum of the courses you take.

What attracted you to UCSB when you joined the faculty in 1966? And what caused you to develop and run the instrumentation program here?

I was offered a job teaching physics. Soon you're in the groove and you don't notice you're stuck. I developed the instrumentation program at UCSB because I realized I wasn't liking standard academia and I didn't fit into it. As a faculty member, your job is to raise funds and write papers. I didn't like that. I liked teaching, but you couldn't tell if you were doing any good. With projects, you can see the results.

I remember back in high school?I went to a technical high school?I made a drill press. It was one of my best projects; I still keep it on my fireplace hearth. There weren't many made; people usually don't make drill presses in high school. What I appreciated most was the self grading aspect of the work; I could tell myself, 'This was done well.'

Standard teaching has long been about courses and labs. Labs are really just recipes and equipment. At first our applications for the instrumentation program for funding from the National Science Foundation didn't come through, so we had students look around campus for projects that needed doing. I noticed later, after funding came through for more formal labs, that the project students did better. They had to think because there was no recipe.

The instrumentation lab allowed us to switch from focusing on teaching to focusing on...
learning. The students had to know more about their projects than I did. The goal for the students was to improve. It was fun to see these grown-up people, for the first time in their lives, surprised to see something they had worked on long and hard didn’t work. One guy was in tears one day. But you’ve got to get the students used to failure, learning from their bad approach to a problem and then re-trying.

It’s all about learning to grade yourself, to learn to be constantly self-correcting. What makes people good is their ability to continue to self-correct, to get themselves out of a maze.

It sounds like there was a turning point in your teaching when you decided you had to approach things differently.

I remember it well. I was teaching Physics I for non-science majors and was discussing Coulomb’s Law about the force of attraction between charges, doing a demo with charged pith balls. I noticed the room was quiet and wondered if everyone was asleep, so I decided I’d start asking the students a few questions. So I said, “What is a fuse?” and I got “I don’t know?” from three students. And then the fourth student said, “It’s like a battery; it burns out.” It was then that I realized I was wasting these people’s time. I threw the textbook on the floor and decided I’d start teaching about the world around us.

I’d ask, “What is a flame?” “How does a phonograph work?” That’s what we did for the rest of the class. But that one day? wow? I wondered why I had never noticed this before. It hurts when you think you have been doing the right thing for years, and then you discover in one minute that you were wrong.
Why is the project focus effective in helping students learn what they need to know?

It's all about learning to grade yourself, to learn to be constantly self-correcting. What makes people good is their ability to continue to self-correct, to get themselves out of a maze. The great thing about employees who know how to self-correct is that they can solve problems they encounter, if they are given the freedom to do that.

How did you go from teaching to starting a highly successful company?

I started with Santa Barbara Technology, in my garage, with a few students in there soldering. I worked with David Nicoli, developing laser light scattering particle sizing instruments, in a firm called Nicomp Instruments. We sold it, and not only did I then have some money to invest, but I'd practiced business and had a feel for how to mark a product up and charge more than it costs, but not too much. The hard part was getting started, getting over the fear.

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Virgil's Maxims

**You can't know what you're doing.**
(Keep your eyes wide open to the possibilities and don't think you know exactly what needs to be done next).

**Hire talent, not experience.**
(No one has any experience in the future, but smart people will do better).

**Get everyone on a different page.**
(If everyone's on the same page, who will find the surprises?)

**Encourage ?negative? thoughts.**
(Keep asking, "What is wrong that needs fixing?")

**Forget the plan and look for the surprises.**
(Tell the difference between how you want it to be and how it really is).

**Customers don't really know what they want.**
(Surprise them. Wow them. But don't look for them to be able to see around the corner for you).

**Choose a path that can be changed at any time, and be**
willing to change it.
(Most people are so married to their plan, they fight the need to change direction because they think they know what they are doing).

Grade yourself. Then you don’t need a manager.
(Be honest with yourself and ready to make regular mid-course corrections).

Fly coach.
(Be a model of humility, efficiency and frugality).

Stay unfocused.
(Highly-focused people ignore surprises and opportunities).

Based on your experience with Digital Instruments, do you think it’s possible to teach management?

Can I teach you tennis by giving you a lecture? I have to give you a racket and a ball.

If it were up to me, I’d get rid of the MBA programs. Why are most of the successful businesses now not started by MBAs?

Universities today: What do you think is wrong with them?

They think course content is very important but in the long run, it means very little. They won’t change. Priorities are such that people still want to do their prestige activities and it leaves the education itself as a byproduct.

Universities like to boast that our students do well in life. To that I say, I’m sorry, didn’t you pick the top 2%? If they didn’t succeed, then I’d say you’ve screwed them up.

So what’s the purpose of an undergraduate education, then?

I used to claim it kept people off the streets, but the drugs and dangers at most universities are just as great as they are in the streets. I guess it gives students four years to think about things and get older before having to set a direction in life.

You know, I’ve never seen a course in academia that teaches innovation, and that’s one of the strengths Americans are supposed to have.

Can a highly creative person survive long in a typical company? And what should companies do to attract the best and the brightest?

No. You can only get promoted in most businesses if you’re willing to kiss your boss’s ass. People get promoted based on whether their immediate boss is happy. A problem with a lot of companies is that they want you to be part of the team, and that can make it hard to voice ideas without causing trouble. It’s easy to get labeled as ?wacky.? And ?wacky? gets to feel uncomfortable after awhile, so people will stop voicing what they
think and be part of the team.

You really have to start your own company or find one that’s creative.

Companies need to hire talent, not experience. You know, you watch movies from the 80’s, and you read the credits, and the people who weren’t stars then haven’t risen up to be stars now. You have to hire star quality and give them the freedom to create.

Twenty years from now, how do you want people to think of you?

That I’m 20 years older. No? seriously? here’s this guy who thought differently than others. And guess what? He didn’t fail.

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