Computer History Museum

Oral History of James F. "Jim" Gibbons

Interviewed by:
Harry Sello

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<*audio begins abruptly*>

Harry Sello: —just from the time we’re starting this recording.

James “Jim” Gibbons: Well, thank you, Harry.

Sello: And it’s my real pleasure to be, as you might say, at the student end of a professor’s comments.

Gibbons: I think “early colleague” end is probably more appropriate.

Sello: Or the one to ask the questions can pose with his own ignorance, and hide it in your knowledge. But it’s a real pleasure, Jim, to have you here, and to—as one of the many, many bright young lights—not too old now, even—in the history of the archives of our museum here. It’s a real pleasure. Well, of course, when I first thought about talking with you, a funny thing struck me: You went to Northwestern University.

Gibbons: I did.

Sello: Now, and I thought to myself, “Now, I was within—I lived and grew up within spitting distance, you might say, of Northwestern University, but I elected to go to the University of Illinois.” So I’ve got to find out, <*laughs*> in the beginning, what led you—

Gibbons: To Northwestern?

Sello: For example, to Stanford, after you had gotten this wonderful education from a Big Ten school <*laughs*> at Northwestern University.

Gibbons: Well, I was doing graduate work at Stanford. My undergraduate degree was done at Northwestern, and the reason I went there was because I was also a trombonist at the time. I didn’t know that I was going to be an engineer. I was in engineering school, but I also played trombone on the side, and played a little bit on Rush Street in Chicago, and so on—

Sello: Well, well!

Gibbons: To make my tuition money. Wasn’t much, but it was enough. And they had a reputation in electrical engineering that I thought, “Well, if I’m going to be any engineer, that’s the kind I’ll be.” So that’s how I went there. And they had a co-op program, so you had to spend every other quarter in industry, and I had a fabulous job in industry with a vacuum tube company. In those days, all television sets were manufactured in Chicago.

Sello: Right, right.

Gibbons: And every tube lab, every tube company—manufacturing facilities on the East Coast still had a lab in Chicago to attend to some of the critical problems that people might have. So, as a co-op student working in that lab, we were all over the place—Motorola, Zenith, et cetera—working on problems that their engineers couldn’t solve. So it was a very enlightening, engaging experience, and because of that, I decided, after I finished Northwestern—I had won a National Science Foundation fellowship. My congressman from East Texas wrote a letter to me to congratulate me on that, saying, “Well, I don’t see any other person from Texas on this list, so you might be the first”... <*laughs*> “and congratulations.” And—but it was—I could take it anywhere. So I had applied at Stanford, MIT, and Caltech, and I’d been admitted to all of them, and so I went to my advisor, the chairman of the department—Electrical Engineering Department—and I asked him, “So, what’s your advice about which place to go?” And he said, “Well, if you want to get right into engineering, then MIT is the place to go. Do your graduate degrees there.” I only had in mind doing a master’s degree. I didn’t think about doing a Ph.D.

Sello: Jim, attach a date to that. What is the...?

Gibbons: That would be 1953 when I’m having this conversation, in spring, and he said, “If you want to do the best science that you could find, then you should go to Caltech.” And then there was a little pause, and he said, “But Stanford, while not the same quality of education experience that the other two were”—remember, this was 1953; it’s not like it is now—“Stanford is the most entrepreneurial of the schools.” And it’s the first time I’d ever heard the word “entrepreneurial” used, and I said, “What’s that mean?” He said, “Well, it means that people think about things differently, and they tend to sometimes start companies, and so on.” I had no interest in starting a company, but anyway, I said—because of the way he said it, I thought, “Okay, I think you’re telling me Stanford’s for me.” And he said, “Yes, your kind of—your style, the way you think about things, I think you’ll be more comfortable at Stanford.” So I came.

Sello: Did you agree with that opinion, or...?

Gibbons: In the sequel, yeah, <*laughs*> as it worked out.

Sello: Well, as of now, but then? Were you a bit antsy about that, or...?

Gibbons: Then? No. I’d—I—as I said, I planned to come and get a master’s degree. It was a one-year program with no thesis. I thought, “Fine. I’ll go in and out of there in a year, and then I’ll be more professional than I am with my undergraduate degree.” That’s what master’s degrees are for still today, and so that’s why I came. But then when I got here, I thought, “If I stay for a Ph.D., I will work in vacuum tubes,” because that’s where I’d grown up. We had one course on transistors in my senior year, taught by probably one of the worst faculty members I can—ever had. He took chalk [ph?] at his book and started at page one, and tried to go as far as he could. And he didn’t understand it, and we couldn’t understand it with the background we had. We didn’t have nearly enough physics because this was an engineering school, and while everybody knows physics is necessary, in those days engineering was a lot more, “Do this, do this, do this,” according to a series of formulas and rules, and not a lot of creative imagination. So I didn’t learn much, and then I came out here, and in my first year, John Linvill came from Bell Labs to Stanford to teach a course on transistors and transistor circuit design. So I took his course.

Sello: So Bell Labs shows its influence.

Gibbons: Bell Labs—he’d been at MIT, he went to Bell Labs, he had become a permanent member of the staff at Bell Labs, and then he comes through Stanford. Yes, indeed —that’s Bell Labs’ initial influence on Stanford. So he teaches this course, I take it, I just have a ball with it. I just can’t get enough of it.

Sello: What was the course called? Do you remember?

Gibbons: Called “Transistors and Active Circuit Design.”

Sello: Wow, right on.

Gibbons: *Right* on. And so we made friends, John and I did, and I was in his office occasionally to tell him how much I liked his course, and to talk about, “This was your problem and—that you gave us, and—but I was trying to do something over here, and I wanted to talk with you about something that was related to it, but wasn’t part of the assignment.” So I did a lot of extra work, just out of interest. So then he said, “Well, you need to stay for a Ph.D., not just finish right there on the spot.”

Sello: Was that—did you have a master’s at that time, or...?

Gibbons: No, not yet. I was getting it.

Sello: Oh, you were getting it.

Gibbons: But—and he said if I don’t—“You don’t have to work in my group”—he didn’t have a group then, actually—“but you do need to stay.” So I took the next two years of that National Science Foundation fellowship that I had, and eventually joined John’s group. And so I finished my Ph.D. It was in a particular way of designing a transistor circuit. In those days, transistors were individual devices, and there wasn’t a manufacturing process available that could produce the same device every time. So there was a lot of variation in device parameters, and the principle job of a circuit designer was not to design the circuit, but to make it—use so much feedback in it that you made it almost independent of what the properties of the transistors were. So I thought of a couple of ways of doing that, and wrote my thesis around that. So then, John having come from Bell Labs, said, “Well, you need to go to the Bell Labs. Join their research team.” So I did, and I worked for the guy that he’d worked for, and—

Sello: Who would that be?

Gibbons: That would be Bob Wallace. You probably wouldn’t know him, but he was—

Sello: I’ve heard the name.

Gibbons: He was just underneath John Pierce in the electronic devices structures area. So I worked with him, and—in fact, on some filtering problems—and wrote a little paper on how to choose Fourier coefficients for filters in a completely different way than people had done before, and wrote a paper on it, and made a little notoriety as a result of that paper, because it was dead simple compared to the regular process. But I had a Fulbright that I had won at Stanford, and I’d told Bell, “If I come, then I’ll need some time off to take my Fulbright.” And they said, “Oh, that’s fine.” It happened that I also had an offer from Tech—

Sello: That was a year kind of a thing, wasn’t it, for a Fulbright?

Gibbons: That’s right, yeah. It was just under a year, actually—nine months. Well, ten months. So then, after being at Bell Labs in the summer and getting this filtering work started, we went to Cambridge for nine months, where I was a postdoc, and I started working then on my first actual materials problem, which was how to use electron paramagnetic resonance as a tool for learning where grain boundaries were in magnetic materials.

Sello: Pretty complex.

Gibbons: Very complex. And it was interesting, because when I started working, coming from a U.S. university, where the equipment that you have is whatever you need, and they’ll buy it for you if you—or your contract, or your professor’s contract, will buy it for you—Cambridge—there’s a storeroom out there with some tubes and some resistors, and so on, and they had an audio oscillator.

Sello: And rolls of wire.

Gibbons: They had a scope that had about a 25 or a 30 kilohertz bandwidth. I don’t know what it was. <*laughs*> But sampling oscilloscopes had just been invented and described, and so I spent at least four or five of my months there learning how to build and calibrate a sampling scope to make it capable of looking at these high-frequency signals that I was going to then try to detect.

Sello: Jim, let me interrupt at this point. Forgive me. In many histories of great scientists, of which I include you—I might not include myself at that time—there are signs in early days—grammar school days, high-school days, senior and junior—of a like or a dislike, which later seems to develop into some sort of a science: a book you read, or a story you heard, or a person, perhaps. Can you shed any light on your early, early days—say, before Northwestern, even, or something like that, to account for your direction? Not that you have to, but it’s just kind of a clue.

Gibbons: Well, I didn’t have any strong interest in a particular subject area. I liked them all.

Sello: Math, physics?

Gibbons: English.

Sello: Even English.

Gibbons: The real—oh, yes. That was my favorite. The real issue in an East Texas high school in those days—I grew up in Texarkana, Texas. That is at the northeast end of redneck Texas, and the things that count there are football, football, and football. And the academics are okay, but we just happened to have in that school system four spectacular English teachers, so in ninth, tenth, eleventh, and twelfth grades, I had an English curriculum that was unmatchable, as far as I was concerned: two Shakespeare plays every year, plenty of writing, plenty of poetry, of course a lot of grammar. By the time you finished that course, those four years, four different teachers, you just—I had a love for literature that—

Sello: How lucky you were, Jim.

Gibbons: And an ability with grammar that was really, really helpful to me. And I never imagined that this wasn’t sort of par for the course, but I found out, as I went along, that that wasn’t the case. But, as I said, I was a trombonist, and I did like math and physics, and so—

Sello: So it was a—

Gibbons: How I chose electrical engineering? I have no idea, Harry. I don’t know why. I thought, “Well, it’s math and”—they said—my advisor in high school said, “You’re good in math and physics. You should be an engineer.” These days, <*laughs*> they say, “How about a mathematician or a physicist?”

Sello: That’s the point I was—

Gibbons: That’s what you were looking for?

Sello: Yeah, I was looking for that, because I felt personally attached at that point. Somewhere along the line, somebody says something that appeals to your background that’s different, and you’re curious about that.

Gibbons: But if they’d said, “You should be a mathematician,” I’d have been just as happy. So it wasn’t that it got me into E.E. It was just sort of, “Oh, well, if you’re good in those things.” This is the kind of advice you got from high schools in those days: what’s practical, not what might you be most deeply interested in. So, anyway, that’s a little bit of an aside, but—

Sello: But that must have helped you in later years in your writing, in your reading, doing papers.

Gibbons: I am a grammatical freak with regard to my Ph.D. students, right? I want it to be done right.

Sello: That’s exactly the reason I asked the question.

Gibbons: Yeah. But... now I’ve lost track with where we were.

Sello: Well, we could jump back in.

Gibbons: But, fundamentally, when I finished Stanford and Bell Labs, and then went to Cambridge, I finished my project, actually, just weeks before, in the meantime, after I’d gotten my oscilloscope working. I also had to make the material—this electromagnetic stuff that had a pair of magnetic resonance in it. So

I went to the chemistry lab to do that—Chemistry Department—and I didn’t know anything about what I was doing.

Sello: At Stanford?

Gibbons: No, at Cambridge.

Sello: Oh, at Cambridge at the time.

Gibbons: So I built this stuff, and the guys that were helping me didn’t do too much. You don’t help students too much, right? They’re supposed to do it on their own. But when I finished, my friend, who’d let me use his facilities, said, “Well, Jim, about three weeks ago, you were at a stage in this project which, if somebody had come in and jumped on the bench, it would’ve exploded, taking you with it.”

Sello: Oh, really?

Gibbons: It was hydrazine, right?

Sello: Oh, for goodness’ sake. Yes, yes.

Gibbons: And that—at least, that was what it was at *that* point of the experiment. But finally, within days, I put this—well, no, painted this on the magnetic substrate, and ran my probe over it, and sure enough, out comes a signal. So...

Sello: What was the substrate? Do you remember?

Gibbons: I don’t remember. It was an iron compound of some kind.

Sello: Oh, I see. Okay.

Gibbons: But it had been ca—it had been not cast; it had been grown in the best conditions possible to get something like a single crystal, but there were grain boundaries in it that would weaken it, and that’s what I was looking at. So I never imagined working on anything like that, and as a result of that, I developed an interest in materials, just because the challenges were big enough and interesting enough that you had to do a lot of engineering work to solve what was basically a physics problem, and that really appealed to me, and that’s probably the first time in my career as an engineer and a scientist that I understood that connection, and how valuable it was to be able to build truly—

Sello: And—excuse me—that was at Cambridge?

Gibbons: That was at Cambridge.

Sello: And was not at the Bell Labs for it—yep.

Gibbons: Was not at the Bell Labs. So I was still a circuit designer at the Bell Labs if I’d gone back, but I also had a potential of a job at Texas Instruments as vice president of their new research group. So I was trying to decide between those two when John Linvill calls me up. As you know, Shockley had started his company in Mountain View, in 1956—February of 1956—and I was still finishing my Ph.D. at Stanford then. I graduated in June of 1956. And I didn’t even know that he’d started a—I knew he was in the area, but I didn’t know exactly how far his company had gone. So, while we were in Cambridge, Shockley went to Stanford and said, “I need some—I’m going to need some fresh young Ph.D.’s to join the team that I now have put together to help this business develop.” And, as is usual for Shockley, he said, “I don’t think you guys are providing the kind of education that students will need to work in my lab.”

Sello: <*laughs*> Amen!

Gibbons: I know—<*laughs*> yeah, for lots of reasons.

Sello: I will back that statement completely.

Gibbons: Yeah. You didn’t have enough psychology to do it.

Sello: <*laughs*> Right.

Gibbons: <*laughs*> So—or psychiatry, maybe. I don’t know. But whatever it was, John Linvill, at the same time and independently, had been thinking, “There’s going to be a revolution out there.” Because he’d been at Bell Labs, he knew this was going to happen, and he came and started the transistor circuits program at Stanford. So he and Shockley got together around this question of how to educate students, and Shockley’s—John’s unstated view—John was like this. He’d have a view of something, but he wouldn’t tell it to you until you’d told him what you thought. That was his style.

Sello: I see.

Gibbons: So he said, "So, Bill"—he knew him from Bell Labs—"what would you suggest we should do in the way of providing education for newly admitted Ph.D.'s that'll be appropriate for this new field?" And Bill said, "Well, you'll have to teach your Ph.D.'s how to build semiconductor devices." This had never been done at a university before, and it wasn't normal to think about electrical engineers as doing this, because you're dealing with a lot of toxic chemicals and all that kind of thing. This isn't E.E., right? I mean, E.E. is circuit stuff with components that are made for you, right, by somebody else.

Sello: That you can buy and—

Gibbons: Of course.

Sello: Hook up.

Gibbons: That's what it'd always been. So John says, "So, how would we do that?" And Bill says, "Well, if you choose somebody, I'll—and would allow them to work at my lab half-time, in a year or so I'll be able to teach them how to do this, and they'll be able to transfer basic semiconductor fabrication techniques to Stanford." So then John called me up in Cambridge, and said, "Look, we've got this deal, and we'd like to have you come back and serve as an assistant professor at Stanford. So you'll teach half-time, and you can co-teach my course with me." So I taught the afternoon session, and he taught the morning session. And then, "That'll just be three days a week, and we want you to learn as fast as you can how to build devices, so the rest of your time you can spend with Shockley, even though it'll be 50-50, in terms of pay."

Sello: Jim, at this point, was Shockley then already in total understanding his way of the surface effects of crystals—

Gibbons: No.

Sello: For which, later, he got a Nobel Prize?

Gibbons: Well, no, that—he didn't get the Nobel Prize for that. He did with Bardeen and Bratton, but it was Bardeen and Bratton that had done that experiment with the point contact transistor.

Sello: Exactly, so—

Gibbons: And what Shockley did was illustrate the kind of truly creative brilliance that he had, which I always admired, and still do; not when it comes to eugenics, but when it comes to solid-state physics. He goes off and doesn’t show up back at Bell Labs for I don’t know how long—three or four weeks, or a month, or something. When he comes back in, he plops down what is, in effect, a basic patent for the bipolar junction transistor, not a point contact device. From then on, junctions are the way to go.

Sello: Right.

Gibbons: So, when he came out here to start his company, it was to make junction devices.

Sello: Which became the spine of his book.

Gibbons: That’s right. So he wrote his book about this, and he decided—I think Bell Labs should’ve treated him differently, but I don’t know there was any way to treat him that he wasn’t going to leave.

Sello: Well...

Gibbons: So, however that goes, the actual thing that happened was he came and started his company, and he, as you know, hired eight of the most extraordinary, unusual people you can imagine, and they all wanted to work for him. And, as you also know, he had them each take IQ tests, because he wanted to know that he was hiring some really smart people. So they came.

Sello: This pins it down to about 1956, I would guess.

Gibbons: Pins it down to February 1956. That’s when he started his lab, and that’s, within a month or so, when all those guys showed up. I think, actually, Bob Noyce was the last to join. He had a great job at Philco having been a Ph.D. at MIT.

Sello: Yes, he was. You’re right about that.

Gibbons: So the group was formed, and six months after that, John Linvill and Shockley are having this conversation, and then—so I was invited to join the faculty, and my first day on the Stanford faculty was actually August 1st, 1957, and it wasn’t at Stanford; it was at Shockley’s. So I can go through a small vignette that might amuse you.

Sello: Please do.

Gibbons: You may already know this.

Sello: Well...

Gibbons: I’m sure you will know it. So he—I show up at nine o’clock, and that was just when my appointment was. Or I showed up at ten till, and his secretary, I didn’t know was also his wife, said, “Well, Dr. Shockley’s busy now, and so please be seated.” And so I did. And 20 minutes went by, and finally, somehow or other, she said, “Dr. Shockley can see you now.” There wasn’t any sign—no bell, no buzz, or anything like that. So I said—

Sello: Was this over at San Antonio Road?

Gibbons: Uh-huh. His office was in the corner. So she says, “Well, just go on in.” He didn’t come to the door, so I went in a little tentatively, and he said, “Please be seated.” He’s behind a desk. And he says, “I like to ask a few questions of my new employees.” And I said, “Fine.” He said, “It’s actually something like a test.” And I said, a little, you know, “What—hmm. What’s this?” I said, “Okay.” So he asked me this tennis problem, which you know, and—I mean, he sets you up to think about it a certain way.

Sello: That’s right.

Gibbons: And I didn’t. I thought about it a different way. I thought, “Well, you got 127 people entering a tennis elimination tournament.” This is *him* talking. “One of them’s got to draw a bye, so you get 126, and 63 matches to start, then 32, and then 16, and so”—of course, a bye comes in to make 64 players of—

Sello: Right, right.

Gibbons: “So, how many matches?” Well, he’s already got you set up to say, “Sixty-three plus thirty-two plus sixteen plus”... you know. But if you look at the end result, you think, “Well, there’s only one winner, and it takes a match to eliminate somebody, so you have to play 126 matches.” Now, it takes a lot less time to think of it and say it than it did for me to think of it and tell him the answer than it did for me to just tell you. So I said, before he had his stopwatch punched, “I think it’s 126.” And he said, “What?!” I said, “I think it’s 126.” He said, “So how did you do that?” So I told him. And he said, “That’s the way *I* do it.” <*laughs*> So I was then shocked. I thought, “Uh-oh! What have I done now?” So he says, “Here’s your second problem.” So he gives me the second problem, gets his stopwatch going, and I can’t work it, and I can’t work it, and I can’t work it. And finally he says, “Jim, you’re twice the lab average on this question now. Would you like for me to tell you the answer, or do you want to keep screwing around with it?” So I said, “Well, you’re the boss.” He said, “I like that answer, so that’s enough of that.” He’d satisfied himself, however. He said, “I’ve got you set to start.” And he said, “Since you’re half-time, you don’t have to answer all the rest of these questions.” <*laughs*> So he didn’t expect me to stay for very long, just long enough to learn how to do this stuff and take it back to Stanford. He said, “Your device coach will be Bob Noyce. Your diffusion coach will be Gordon Moore. Your materials coaches will be Jay Last and Sheldon Roberts.” And then—and he told me a little bit about Jean Hoerni; says, “It’s a little hard for me to imagine what he might do, but you’ll want to get to know him.” And, of course, Vic Greenwich was my circuits coach for four-layer diode things.

Sello: Had you met Vic before?

Gibbons: No.

Sello: All these were new to you?

Gibbons: Yeah. This is August 1st—yes, August 1st, 1957. So I go out the door, and there’s Bob waiting for me, and the first thing he says is, “So, how’d you do on the test problem?” <*laughs*> I said, “Is this standard?” And he said, “Yeah, it’s standard. We did much tougher stuff, but”—I said, “Well, I got that one.” And he said, “You probably scared the living daylights out of him.” I said, “Well, I didn’t get the second one.” He said that was good. So he showed me around, introduced me to everybody. Six weeks later, Harry, they left. On September 19th, 1957, they left Shockley to form Fairchild. There’s an entry in Shockley’s diary, saying, “They left today,” on that date.

Sello: Jim, I’m—

Gibbons: So they were there. My device coach, my diffusion coach, all my coaches were gone in six weeks, and I’m supposed to get a lab going. So I’m thinking, “Oh, dear me.” Actually, Noyce came around and said, “You know, we like what you’re doing here, and we like your interactions. Would you want to join us in the—we’re”—this is just before they left. “Would you like to join us in forming this company?” And I said, “No, no. I’m here to help Stanford build this lab, and that’s what I’m going to do.” It could’ve been the most expensive decision I ever made, <*laughs*> but it’s not—I don’t regret it for a moment. So then I had only Shockley. And Shockley had made a commitment that meant something to him. He’d said to Stanford, “I’m going to help this guy learn how to build devices and set up a lab to do it.” So, without saying anything else—he didn’t say, “Oh, I’m sorry your coaches just left.” He just said, “Well, where are you in developing your lab?” So I told him what I was doing and where I was having some troubles, and what my next question to Gordon or Bob was going to be, and he said, “Okay, then here’s the guy to go talk to.” But it was somebody in Bell Labs, or someplace like that. And he—

Sello: It wasn’t anybody, then, on San Antonio Road at that time?

Gibbons: No, there wasn't, to do what I needed to do. So he helped me get in touch with everybody I needed to be in touch with, and they told me over the phone, "Okay, well, do this do this, and then if it doesn't work, call me back," right? I mean, the telephones are what you had. So, gradually, I put the lab together, and Shockley kept on top of it. Every time I'd come in there, at least once a week, he'd say, "Okay, let's spend an hour talking about what you're doing," because, of course, he had other assignments for me in the lab. I was a full-time member of his lab, too, so I was doing circuit designs and going out with the sales team to try to help sell PNP and diodes, as the engineering member of the sales team. So I was doing whatever it is he wanted me to do to help him forward his company's interests, and—

Sello: Was [Maurice] Hanafin at all involved at this stage?

Gibbons: Hanafin had just gotten into—when this—when the Fairchild Eight left...

Sello: Hanafin came aboard.

Gibbons: Hanafin came on board, and so I also had Maurice to help me a little bit, with regard to dealing with Shockley, because that wasn't always a piece of cake. But I did admire the fact that he was completely dedicated to causing this thing to happen, and it had nothing to do with his future success as a commercializer of transistors.

Sello: Understood.

Gibbons: So—and you couldn't help but have a lot of regard for that. And we did get the lab going, and the judgment that everybody'd made is, "Well, it'll take a year and a half to get this going." Six months later, from a cold start on August 1st, we built our first silicon device in that lab at Stanford that I'd set up—the first one that had ever been built in a university anywhere, as far as we knew. We gave a little conference paper on it. And all of a sudden, the world changed... for Stanford, because now we had this lab. So then...

Sello: You knew the technology.

Gibbons: We had created enough technology to be a real interest to people who would like to be at a university, but needed some kind of a lab to do their experiments. So here I had, with a lot of help from Shockley, created this lab. So, very quickly, John Linvill's back at Bell Labs. He hires Gerald Pearson, he hires John Moll—I mean, people of extraordinary reputations already in the field of semiconductor technology and circuit design, and so on. So those were the first—so he built—because of this lab capability, he built a solid-state electronics laboratory on top of it with some of the best-known names in the field. So, five or six years later, Stanford had a completely new division of electrical engineering, all based on semiconductor technology and having a lab that supported all the experiments that those guys were going to do. Now, we did, of course, develop the lab further as a result of that early success, but John built a lab that nobody could touch. So then, the sequel to this story, I think, is really interesting, because it shows what Stanford has done since that time to become what it is with regard to semiconductors. So, among the last people Linvill hired into the solid-state lab was Jim Meindl, and Jim had been working—by then, that was 1970 or so. The integrated circuit had been invented. And Jim was in the solid-state lab, but he and John and I talked about what might make sense in regards to integrated circuits, and Jim said, "I've had experience with this at Fort Monmouth in setting up some things, and I would like to set up an integrated circuits lab." So it was spun out of the solid-state lab. This begins to sound like companies that do something, and then they spin out a division—well—

Sello: They spin out and do something else.

Gibbons: So now we form an integrated circuits lab and start hiring faculty into that. Jim Meindl was a director of it until he left Stanford to go to—as a provost to Rensselaer, quite a time later. But we developed this integrated circuits lab. So now we had a solid-state lab and a twin integrated circuits lab that provided both physics and technology, and then actual fabrication of integrated circuits.

Sello: And then working with your hands to put—

Gibbons: And creating masks, and everything you had to do to make an integrated circuit. So whatever happened in Silicon Valley, we were not that far behind in saying, "Oh, do we need to do that at Stanford?"

Sello: You hadn't started.

Gibbons: So it wasn't that long later—Jim came in about 1970. By 1979, it was clear—the microprocessor had then been invented, and we're looking at ourselves, thinking, "We're going to need a new lab, because the I.C. lab might build some simple microprocessors, but we're going to need a lot more capability than we have in that little lab in the basement of the McCullough Building to actually build integrated circuits. We've got to build something—build circuits that are capable of being microprocessor-like circuits." So we started, in 1978, to build what then became the Center for Integrated Systems, focused on the software and hardware of real integrated systems. So this is now not just doing hardware, which is what the solid-state lab and the I.C. lab had done, but recognizing that software was going to play an increasingly important role in the development of systems, and that we needed a lab to do that. And we needed the support, both financial and intellectual support, from what was then Silicon Valley, by then a fairly well developed thing. So, Stanford's history and position in the field went from nothing to the leader very quickly because we had these labs. And then we built this new lab.

Sello: But nobody else had those kinds of labs in history.

Gibbons: If you didn't start—you had to pretty well start where we did. You had to build a lab to build your first device before you could do anything else. And by the time it got to through integrated circuits, then there were plenty of companies building integrated circuits. And most electrical engineering departments just did what they had always done. They'd buy integrated circuits, eventually buy microprocessors, etc. and build circuits with them. That's what EEs had always done, buy the hardware and stick together. But this was different. This was no, no software's going to drive the hardware. You're going to put the software program in the memory, and then it's going to tell the microprocessor what to do. So, as soon as that became clearly a new theme, we developed the Center for Integrated Circuits and brought nineteen different companies into it. And I was responsible for talking to all of those companies, both to get support from them, it was twenty companies at a million and half per company to build the entire building with all the facilities in it—

Sello: What did they get for there million and half?

Gibbons: Well, that's an interesting conversation. Everybody thought, each company thought, we're going to get to have special purpose customized integrated circuits built in this new lab. And I kept saying no, we can't do that. This is a university laboratory. What we do is open to the world. But if you join this community, you will be participating in the research projects that we choose to do. So, they have some long-term influence that you would like for them to have, make sure there's some longer term research, which is what the university does best.

Sello: Academic research?

Gibbons: Academic research, but focused on things that had long term—potentially long term significance for the semiconductor industry. So, then the question came down so what about patents. So, there was a time when I'm sitting in a room with nineteen different patent attorneys. And they're all saying I'm—you didn't bring your wits with you today when you thought we were not going to get patent rights to this. As it turned out, John Doyle, who is helping—he was at HP and was a member of this group. He took me under his wing, and he said let me take over for you in this patent stuff. And I said fine. So, he persuades all of these guys that all of the IP that would developed in this center, from donations that the companies made to the center, there would be no patent rights asserted for that. What the companies would get is a six month, at least, or a year lead on what was—how that technology was developing. And they could go home and proprietarize in their own way. So—

Sello: Without any further drainage of information—

Gibbons: From Stanford. It was all available. Whatever we did was available to everybody. But, for example, IBM was in this. And they had actually—the patent on the RISC architecture approach to computer architecture, they had the patent on. But John Hennessy at Stanford and Dave Patterson at Berkeley started teaching courses in this and having PhD students in it. So MIPS, the corporation that got formed, spun out of Stanford with John and then several other people—students, but then a larger group from outside Stanford, was the first to actually commercialize MIPS technology. But at the same time, Sun was a member of the group. So, they built a SPARC station independent of Stanford. HP was a member of the group. Their SPECTRUM set of equipment also had risk processing in it. So, that was exactly the way it was supposed to work. It might be that the technology would lead to a company being formed. But, in any event, the technology would allow companies to decide what use they might want to make of it on their own. So, it sprung up in products—

Sello: Totally independent.

Gibbons: Totally independently. So, that really was a brand new thing to happen. And it built a connection between Stanford and Silicon Valley that was completely new and was recognized as being that. And we got not just enormous points for that. And then when we would go to the DoD or somebody to look for a grant, our grant proposal had in it some researchers from industry who were part of it, and it had all the insights they could bring to it as to what would be the right research to do for the long term. So, I guess, to summarize this, Harry, you start with a solid state lab in 1957. And by 1963, it is a very solid property in academic circles. And the IC lab spins out about 19—I don’t know what it was, ’68 or ’70 or something like that. And that develops. And by the end of that decade, by roughly 1980, we had built this new system. And, three or four years later, when I became dean, we brought the computer science department into the school of engineering because a lot of this software work—

Sello: What date do you attach to becoming dean?

Gibbons: August 1st 1984. That is the exact date.

Sello: Surprise.

Gibbons: And a year later, we had—a year plus later, we had moved the computer science department in to the school because in the early days, computer science was part of mathematics, applied mathematics. And that was appropriate. They were doing mathematical theory and developing theory for algorithms and so on. But before too long, computer science becomes an applied discipline. And that means it’ll have a more comfortable home in the school of engineering than it will in the humanities and sciences where it then was. So, I had to persuade the provost and the computer science department that the school of engineering would be a happy home for them. But if they were willing to move, I wouldn’t merge them with EE, which is what everybody else has done. MIT has an EE-CS department. Berkeley has an EE-CS department. Everybody does except us and maybe Princeton and couple of others. I kept CS department separate because there were plenty of applications for computer science, applications of it in psychology, sociology, and language studies, and all that. So, I wanted it to be the broadest possible resource for Stanford. And they were only a graduate department, so I said we’ve got to build a terrific undergraduate program in computer science.

Sello: To lead up into this.

Gibbons: To lead up into this, and to provide a lot of interest from students from a lot of places. So, they might be engineering students in EE, but they could take a lot of courses in CS. Today, something north of ninety percent of all graduates of Stanford take at least one computer science course. It’s the most popular un-required course in the university. It’s the first course in computer science. And there’s several versions of it, depending on how—

Sello: And we thank you for using the words computer science in this building right now.

Gibbons: Right now, this is—

Sello: Jim, may I interrupt please? And shut me off if it’s out of line. When you started putting together, at Stanford, the coursework, or a place for students to work as according to the good advice you got from Dr. Shockley, no question about it—my question relates to, did you have any interaction with the four layer diode, at that particular time? When did—?

Gibbons: That’s what I did for Shockley. And when I left—

Sello: You worked on the four-layer diode at the Shockley Laboratories?

Gibbons: Yeah. And I was—

Sello: On San Antonio Road?

Gibbons: Yes, Sir. And then when they moved over to—

Sello: Clevite.

Gibbons: To Spinco [a division of Beckman Instruments, the backer of Shockley].

Sello: To Spinco, right.

Gibbons: To the division. Yeah, I stayed with them. And after my term was up, Shockley said well, you know, you’ve done a lot of circuit work for us and helped us win some contracts and some jobs and so on. I’d be happy if you wanted to stay on as a consultant for a day a week, which is all I could do. So, I actually worked for Shockley, or for the organization, for seven years until I came to my first sabbatical. But then, I wasn’t tied to him the way I was to start. So, after the first several of those years, I did some consulting with other companies.

Sello: Because you had this mainstream objective of teaching?

Gibbons: And I eventually—Gordon Moore asked me to come and teach a course to the scientists—leading folk there were at Fairchild when they were in that nice brick building next to the VA Hospital.

Sello: Which leads—you’re talking about [duplicated audio] the folk at Fairchild, which leads me to ask you…”did you organize this nice system that we established at Fairchild R and D?”

Gibbons: And elsewhere.

Sello: At that time, to take coursework from Stanford over the television set?

Gibbons: Yeah. So, let me—what we’ve been talking about so far is how the school of engineering developed to essentially the position it’s in now, just—I’ll just finish that with one little point. When you get to the stage that we got with the Center for Integrated Systems, now it’s not just EEs trying to build those things. It becomes the entire electrical engineering department realizing that there will be such a thing as a fabless semiconductor technology that develops. And that means that all the people in the information systems laboratory, for example, who had no interest in how things were built, but they wanted to know how to use them in sophisticated systems problems, so they began to design their own chips. And, for example, John Cioffi and the Amati—the digital—the DSL company that was spun out of Stanford, those were all potentially fabless semiconductor companies. So, a lot of that’s been done. So, effectively, people in all branches of science at Stanford do this. If it’s medical science, they’re designing little test chips for doing multiple tests for deciding how drugs are going to interact and all that kind of stuff, and little wells. The whole—

Sello: Hard of hearing and seeing.

Gibbons: Everything. Chips for that, and then measurement of things using specifically designed chips and technology. So, Stanford has just been on a roll with that from 1957 on, entirely because of watching what industry was doing, seeing a breakthrough, and picking it up and running with it. So, that’s also something universities don’t tend to do, look for intellectual leadership outside. But that’s exactly what happened because the intellectual leadership that led us into the IC lab didn’t come from us. It came from Fairchild. When they did it, we saw it. We saw what they were doing. And we thought okay, we need to do that because that’s really going to grow. Ditto for the microprocessor at Intel. When it happened, we took the idea and built a lab to—because we saw it would be that important, and brought in more faculty. So, when you see faculty growing, that’s the fundamental way to tell how healthy a university is in a field are new young faculty, continuing to join in areas that are different from where they started. And there are still new young faculty interested in being in the solid-state lab and the integrated circuits lab. So, all those things bore fruit on their own, and over the university, had a much larger impact. So, it was a rather substantial thing.

Sello: And these new young PhDs, etc. learned about the outside world’s interest in that entire solid state field.

Gibbons: Yes, in everything. And then they take this stuff, every time we do something significant, it means PhDs finish. And they go, either to industry, or they go to universities and start setting up labs there. so, we seed a lot of different kinds of stuff this way in the university community. But when it finally gets to the stage where microprocessors and memories and all that kind of thing are now available to everybody, then what happens is the normal course of EE picks up again. And nobody thinks they need to do what we did to get there. But, in the meantime, if you want to do that kind of stuff, we’re the only game in town. So, but you wanted me to—you asked me about TVI and Tutor Video. And I’ll—

Sello: Well, yes I did. That was—

Gibbons: Take off on that if you want.

Sello: Yes, please go ahead. I can think of a number of other questions, but please—

Gibbons: This one had also—

Sello: TVI, television instruction.

Gibbons: Tutored video instruction. All those words are chosen for a reason. So, I happen to be serving on the science advisory committee for President Nixon at one point in 1970 and ’71, I guess, or maybe it was ’71 and ’72. I don’t remember exactly, but one of the subjects that we were studying was technology in education. And shortly after the conclusion of World War II, the Ford Foundation put a lot of money into experiments to compare televised instruction with classroom instruction.

Sello: Excuse me, by the way, how do you feel about a break? Are you—?

Gibbons: I can keep going. I don't need one now.

Sello: All right.

Gibbons: Let's finish this, and then maybe a short break.

Sello: You didn't even take a sip of water or anything. You're remarkable.

Gibbons: Well, it's a subject that I love. So—I mean talking about Stanford. So, we were looking at this for—so, we were looking at—the department of education—do you need a break, yourself?

Sello: No, no I was looking for my water bottle. Here it is. He put me up on a highchair.

Gibbons: Yeah, that's right.

Sello: Couldn't reach the water bottle.

Gibbons: You be careful you don't undo your mic there.

Sello: Good, thanks.

Gibbons: So, the department of education, then a stand alone department, and the Ford Foundation, over a period of a decade, had funded experiments in television versus classroom as a means of delivering education over every subject from mathematics to fine arts, and every grade level from K through a baccalaureate. So, a huge matrix of experiments. And all of this stuff had been studied fairly deeply and inclusively by about 1970. And that was what we were looking at.

Sello: Can you open that for me, please?

Gibbons: And the result of those studies was, three hundred and sixty-three different studies across all—as I said, all subjects and all audiences, there was no significant difference between whether you received you instruction in a classroom or whether you received it from a video, which was just a video of the classroom. There was nothing done in the video to make it different. It was just I made a video of a classroom, and then I showed to another classroom. So, no significant difference. And I thought if you use technology correctly, it should make a significant difference. And it's one of those times when I was getting on the airplane to fly back to California, and I thought I think I got an idea. So, I wrote it up on my way back, submitted it to the President's Science Advisory Committee. And everybody thought oh, yeah. That's interesting. It would still be buried in the bowels of the White House, except for the fact that, essentially after I'd written—shortly after I'd written this paper for the PSAC, HP was moving its microwave division from Palo Alto to Santa Rosa. Now, we already had this closed circuit television system. So, you could be at Fairchild or HP or GE or wherever you were in Silicon Valley and, when the course was being offered at Stanford, say nine o'clock in the morning, there were facilities in your company where you could go and watch the course live. And you had an FM talk back link, so that you could ask a question if you needed to. That technology for distributing classroom materials, educational materials, had been in place for six years, or something like that. I guess it was put in place at Stanford in 1967. And this is 1970, or so, we're talking about. So, it's three or four years later. And I thought well, what you need to do is to separate the learning environment from the dissemination environment. And technology should allow you to do that because a classroom is a room—is a place where the professor is lecturing. He's disseminating the information, but you're also supposed to be learning it. Now, there's problem sections and all that, but you've got to learn from the lecture which way you're going and what—something about how to work the problems, and so on. So, there are a lot of questions. But there are a lot more questions than the faculty member has a chance to answer. So, that's what I mean when I say we need to separate the real learning environment from the environment where it's taught.

Sello: Jim, doesn't this relate to what we used to call quiz sessions?

Gibbons: No, or problem sessions?

Sello: Attached to lecture sessions?

Gibbons: Here's the problem. In a quote quiz session, or a problem session, what happens is there's a guy there to help you solve the problems. And maybe you go, and maybe you don't. And, by the way, he says the thing that's wrong here was the lecture wasn't very clear. So, let me give you the lecture. So, now you've got another dissemination thing going on. And that isn't exactly going to get you where you need to be because now you've got a couple of different kinds of influences. And that's okay. But the student doesn't profit too much from that. So, my idea was here's what I'll do. I will tape the lecture exactly as it's delivered with all the warts and blemishes and the questions that arise in it. And then I will send that—I'll use that material for my remote class. So, I imagine that this is a remote class, not a campus class. The problem sessions, the quiz sessions are on-campus events. So, I'm not going to do that. I'm going to say the students are out there somewhere. So, and what I'm going to do is imagine that they are going to watch this lecture in a small group with a facilitator. This is what I'm writing on the way home from Washington. They're going to watch it with a facilitator who can't teach the class. He will know something about it because of the work he's done in it. And he's interested in refreshing himself in this field. But his main job is to run the tape with a small group of students. You have to figure out what the group size should be, and what the characteristics of the tutor should be, or facilitator. I called it tutored, but it would have been better called facilitated because that's closer to what it is. And then the tape will stop every time anybody has a question. And it stays stopped until everybody first of all understands what the question is, and then they try to answer it. Well over fifty percent of the time, when the tape stops, it's because somebody was gathering wool. I'm sorry. I wasn't paying attention. Would you mind replaying the last couple minutes of this tape? He isn't the only guy that had that problem. And it doesn't hurt to replay the last couple minutes of the tape. So, the students are managing the lecture on their own behalf in this way of doing things. That is critical because now the learning audience has this material that they're trying to learn. And the way they're learning it is saying we'll stop it whenever we need to. It'll stay stopped. We've got our facilitator. What happens when there's a real question is they try to answer it. And if they can't answer it—most of the time they can if they think about it long enough. That's what the facilitator is supposed to be doing is drawing every student into answering that question. But if they can't, and then he can't—he will tell them if he knows, but not to start. Then he will, if it's my class, he'll call me and say Jim, we've got this problem. And now, when he calls, the question he asks me is not where it started because it started on place, but then the class and all the thinking they did about it and so on, it's a new question.

Sello: Yeah, it's the collection of all that.

Gibbons: It's a collection. And it's a vastly better question. So, I say how long are you going to be there. and he says I'll be here for an hour. So, I call him back in less than an hour having looked at a few books on my shelf and saying have your students read these pages of this book, and these pages of this book and work this problem. And I think you'll have it made. So, they're using me as an intellectual resource for the whole material in the field much better than my on campus class can because they can't do that. They don't have a chance—

Sello: And you can't see them in a big class, at all.

Gibbons: Furthermore, they don't want to ask too many questions because I'm also the judge. And they don't want me to think they're stupid. So, there's a certain psychological barrier between the class and me with regard to questions. Not that I want it to be that way, but it just plain is that way. This completely removes any stigma for asking any question you want. Everybody always starts saying this is a dumb question. Well, it's not a dumb question. There aren't any dumb questions. There are just questions. And sometimes they're easy to answer. And the guy says yeah, okay I see. I needed a different perspective. And somebody supplies it. But you've got to have a group that can work together. And when you get too large a group, you begin to get some of the bad dynamics that go on in a classroom. So, we had a lot of work to do to figure out how big the class should be, etc. But, remember now, this is an HP remote site in Santa Rosa. So, they can watch this anytime they want. It isn’t because I gave my class at eight o’clock in the morning that they have to be there. They watch it when they want. They do all the homework, all the assignments. And they take all the exams the same as the on campus class.

Sello: And you, as the professor, get that wonderful feedback of the collected ignorance of a quiz class that you would never have gotten by an ordinary university quiz class.

Gibbons: Right. And these questions never would have arisen and been developed the way they were because they could replay the tape. Oh, oh that’s what it was. Also, with regard to faculty, really interesting. You have some faculty that you remember thinking they were just terrific. And you’ve got others that you remember thinking they were terrible. Blah. So, now, you’ve got faculty on tape, and you’ve got remote audience. And you ask yourself let’s make judgments about what they think of the faculty teaching the class to compare with what students on campus think. All of a sudden, things get reversed. The thing people like about a really good faculty member is he tends to be spellbinding. I mean you just oh, yeah, wow, wow. But then when you leave the lecture, you can’t remember what did he say about this and what’d he say about that. He smoothes over everything. We learned this because one of the worst lecturers on campus was somebody whom when a student asked him a question, he’d start trying to answer it. He’d realize internally “I can’t answer it that way.” So, he’d start over. Now, in class, you think what’s he doing. And he’d start over again. And then finally he’d get on a track where he could answer the question. So, three starts finally led to the right answer. I’ve got TV data to show this. Turns out that if you’re a student in this remote environment, every time he stops, somebody says what’d he stop for. So, the class starts thinking why did he stop taking this approach. And they figure it out. Oh, well here’s a problem with that. And they go to the next approach. So, they’re even learning from the ways that the faculty answer the questions a lot more than anybody in class can. In class, you’re sitting there drumming your desk thinking would you just please answer this question instead of fumbling around it.

Sello: Yeah, and keep going.

Gibbons: Keep going. So, it’s a very, very different learning experience. It’s called, these days, collaborative learning. The school of education started working on it ten years later. And when I showed them what I had, they said it’s interesting that you’ve worked on what we’ve invented. *<laughs>* Well, okay I don’t—But, here’s the real piece de resistance to this. These guys had to take the same exams as everybody else. So, [duplicated audio] I insisted that they come to the campus to take the same exam in class because I knew if they did well on them, some faculty would say yeah, but they’re up there, and they’re talking to each other. And that’s not fair.

Sello: And they’re cribbing and all that sort of stuff.

Gibbons: So, I had them come to campus. The results for the first two quarters were that all of these students outperformed the on-campus students hand over fist. It wasn’t even close. I’ve got plenty of data on this. And so, then I got colleagues who were trying to explain why that’s the case because they want to believe that somebody sitting at their feet can learn more than somebody learning from a video tape of what they said. So, then we ran a long experiment for eight years. By then, it was Fairchild—the first place to do it was Hewlett Packard. But then it got to Fairchild and GE. When you saw it at Fairchild, you were the next company to use it. But it got to the point where anybody who had any industrial affiliation with Stanford could sign up for this program. So, Hewlett Packard had it at every single laboratory around the world. And they realized that they could start new labs in Boise, for example, where they didn’t yet have a plant, and say we’re never going to be out of the range of a Stanford graduate education because, when we proved it worked well enough, we said we’ll give you a masters degree for the work that you do, since it’s entirely equivalent or better than what you would have done on campus. Furthermore, we found that students that would never be admitted to the campus, still did extremely well because it was a different learning environment. So, a campus learning environment is one thing. And if you’re really fast and you can deal with some uncertainties and work them out, great. But if that’s not your learning style, that doesn’t mean that you can’t learn the material. You just need—

Sello: It doesn’t mean you’re dumb.

Gibbons: It means you need a different way to work with it and have some colleagues that can help you at the coffee urn and wherever you are. So, having this be on site turned out to be really important. John Young, then—when we started this, he was executive VP for the microwave division. But later on, when he became CEO, there was a big conference at MIT in 1983 on the hundredth birthday of the MIT EE department. And John was the keynote speaker. And he went to MIT and said this use of technology—this use of faculty members’ knowledge has increased his productivity without decreasing his efficiency or effectiveness one bit. And you need to do it, talking to MIT. By then, we were in Amherst. We were all over the place. And so, their announcement for the—coming out of their first hundred years was we’re going to start doing this kind of distance education.

Sello: Jim, what are the financial implications here? Does a school pay, or Fairchild research group pay?

Gibbons: So, the real cost—very good question. The real cost of education, course by course, is roughly twice what the tuition is. You can’t charge the real cost and expect anybody to be there.

Sello: It’ll be too much.

Gibbons: Yeah, way too much. So, what we asked the companies to do was to say since we’re providing this service to you, this was Fred Terman who put this in place in the co-op program. He said I’ll set this up for you—when he was dean, but you’ve got to pay the real costs of education, not what you would pay if your student was on campus. That's about—so, that was twice tuition plus a little bit. So, the university was making money on this hand over fist.

Sello: They were getting their tuition money.

Gibbons: All of it. And so, turned out that the school of engineering with that and all of its research programs and so on became a cash cow for the university. It wasn't just because of this distributed education stuff. But it became a cash cow. The only school that ran in the black in the main campus. Not law school, not business school, not medical school, just the undergraduate part of the campus. And most everybody else was in the red. And we were in the black enough to float them. So, we became the provost's heroes, right? But it was everything. It was TV. And it was a lot of other things we did in our general research and the kinds of money we got from companies to run the CIS and all that kind of thing. So, huge interaction between Stanford and the industrial world including both, now the technologies and education. So, here we were doing both teaching and research with corporations. And that's what universities do. So, it was really expressing both the teaching and the research components in a way that didn't compromise the university in the slightest, but allowed us to help companies that wanted graduate education. So, it wasn't just master's degree students. For Hewlett Packard, it was everybody who wanted to take a class in their engineering staff could take it. If they got an A, HP would pay for the tuition. If they got a B, HP would pay half of the tuition. And if they got a C, the student paid all of the tuition.

Sello: You answered my next question was the cost incurred by the Fairchilds and the HPs who had these classes going on their premises?

Gibbons: Yeah, and a large number of them, eventually, because we had then course sequences. You could take—I taught the undergraduate electronics course, and then Jim Plummer, now the dean, taught the next course on transistor circuit—on integrated circuit fabrication and design to satisfy certain outcome circuit objectives, and so on. So, there's a little package of courses that the company could sign up for and get a slight break on that. But we made a lot of money on that. We didn't—the faculty couldn't continue to be the deep resource for this course as it got evolved and scattered all over the world. But we were with HP in Guadalajara, and Grenoble, and Bristol, and Yokohama. Wherever they were, we were. And that, HP—if it hadn't been for that, probably the program would have died. But they were so enthusiastic about it, stopped doing live video in favor of this at all of their locations and began to hock it to even their competitors, IBM, and everybody else. So, it was—it was an idea that happened to work. But it would never have seen the light of day if HP—if John Young hadn't called John Linvill to say we're moving a lab up there. We've got some honors co-op students. What can we do about it? Linvill says Jim's just gotten this idea on his term of service PSAC. And do you want to try it? And John Young says sure we'll try it. We've been thinking about video anyway. But what they didn't have was, of course, this separation of the learning environment from the dissemination environment, which is what it is that causes the thing to work.

Sello: Exactly.

Gibbons: We have now used that technique, Harry, in all kinds of things, helping science teachers in the public school system. A thing I’m most, in some ways, happiest with, I guess proudest of, is teaching juvenile offenders in the Santa Clara Juvenile Hall.

Sello: So, it’s still going on?

Gibbons: Oh, yeah. Santa Clara Juvenile Hall, the corner of Guadalupe Park and Hedding, how to manage their anger and walk away from fights inside juvenile hall. We proved that we could do this to a level that no one had ever seen before, so that got us into juvenile halls around the state and into schools that served those juvenile halls. When Columbine happened, the disarray that it caused in the student body was such that the DA for Jefferson County and the superintendent, the DA said, “We’re going to get sued by the families of the kids that were killed, 13 of them, and we’ve got to do something besides grief counseling in the school to respond to this.” So through a series of things that I won’t describe, he ended up calling me to say, “I understand you’ve got something that might help.” So I went to talk to him and we put this program in place in Columbine High School and in the middle schools that feed it and we just changed the culture of those schools and got kids realizing that they need to be colleagues, not competitors. It had an impact way beyond what I—when 9/11 happened, Harry, now the entire New York school system, 25 different school districts in the board of education in New York, a teacher out in Long Island, not inside this, started using our stuff and said to one of her buddies in Harlem, “You got to use this because we’re able to handle these problems of anxiety and tension”—everything that goes on in the juvenile hall and goes down on the streets except that here’s a way to begin to conceptualize it and handle it because you’ve got a lot of examples of things. If you look at these tapes, what you’ll see is they don’t look anything like a lecture. They’re little bitty pieces of events where you get to when a switchblade would be drawn and you stop it and you use that to help people learn the dynamics of violence and how they can deal with it. So that was—

Sello: And you can teach how to avoid it and how to—

Gibbons: That’s the idea. So we were in 13 of the 25 at the peak of this. We were at 13 of the 25 school districts in New York City. We were all over Jefferson County and doing a lot of juvenile hall work and so on.

Sello: Are you still involved in TVI?

Gibbons: Well, Harry, what’s happened is this. When—

Sello: If not, why not?

Gibbons: Well, good question. When state budgets hit the tank in the year 2000—I started this in 1996, the year I left the dean’s office. We had the program developed before that, but then I built a little company to do this, a for-profit company. Wanted to prove that you could make a profit doing something that was a good thing to do. Social entrepreneurship. So we did. For five years we ran the company and we netted two and a half million and we got the price down to a dollar per student for our skills for managing anger course. So the Dallas Unified School District had 25,000 students in it. Our bill to them was $25,000 including training for all the people who were going to be facilitators and so on. So you had the TVI principles because all this was on video, but then you had the facilitation was a lot of different stuff. Role-plays where two people would in a group try to drive each other to real anger by hitting their hot buttons, finding out what they were, and just being relentless. That’s what happens on the street and that’s what you have to have as your lab. You’ve got to have a lab that allows you to do that. So that’s the way we built the course to take advantage of all the things we knew about group learning and how the culture changes. I guess one of the most interesting examples was in LA County. A guy named Roy Romer had been governor of Colorado and he knew about this and when he went to be superintendent of schools in LA County—

Sello: I remember that move, yes.

Gibbons: —he had 85 middle schools under his purview and 15 of them had crime records that were at least as bad as crime records that bring people to juvenile hall, so he says, “Jim, I need to have you work with these 15 schools and see if you can make anything happen.” Well, we got five to start. They didn’t have a lot of budget and we were for-profit, right? So these five schools, also at that point if your academic performance index in a school didn’t improve by a certain amount each year, you might not be a school next year. So that was part of the drive to cause sort of “some kind of an incentive.” Well, how good the incentive was, I don’t know, but we went to the two toughest of these schools to start and we gave them our skills for managing anger course for a year, repeating it several times. There’s a six unit version and a twelve unit version, so we just kept repeating it and each time you do it, it’s different because now people’s experiences are different and they know some of this stuff, but they realize, “Oh yeah, here’s some other things we didn’t learn last time or didn’t use last time.” You can give this course repeatedly and people learn every time, but what we did was we changed the culture. The first course is skills for managing anger. The second was a negotiation course that we’d developed. So the culture of the school changed, their academic performance went way up, and I have a speculation, sir, that if you plot on a vertical axis academic performance based on grades and on a horizontal axis emotional skills, there would be a curve that goes up and to the right. The more emotionally skilled you are—

Sello: The smarter you get.

Gibbons: —the better you’ll be able to do your academic work. The brain cells didn’t change.

Sello: It's the way they're being used.

Gibbons: It's the way they're being used and the fact that you're not afraid. The fear and the anxiety and all that kind of stuff—the culture of the environment changes and then it becomes a better academic organization. That's what's happening. They become accustomed to doing things in the school the same way that the TVI guys had done it except they've got to first manage their anger and walk away from fights because that's the kind of school they are. So first you got to teach them the culture that's needed that's usually available except that places like Columbine—the Columbine education system's every bit as good as the Palo Alto system, but you still have these crazy things happen. So you still have to teach kids emotional skills and I believe that no child left behind, the best thing you should do to start is teach them the emotional skills that will allow them to be the best student that they can in a group that is also doing the same thing; that you can improve a school and its students' performance in it by teaching emotional skills. Budgets go in the tank, schools can't afford us anymore, and we're shut down. So we did a little bit after that, but we couldn't make it be what we wanted it to be and so now what happens is juvenile halls that we're serving, I am the company. They send me. Okay, we need 100 more student notebooks and we need this for our parents' orientations when they do parents' orientations, big positive. Everything. So they call or they send me an email and I go down to Kinko's and I reproduce as many copies as they need and I charge them for the production costs and the mailing costs and it's for free. It's not for free, but my time is for free and there are places that have been doing it for I don't know how long, but at least ten years.

Sello: Jim, why should your time be free? That's you speaking from the heart.

Gibbons: Yeah. I don't mind putting my time—if I can go someplace and cause something to happen that after that they are going to do and they need materials that I have, yeah, if it were a huge drain then I'd say yeah, I've got to do something. I'd have some people help me, but as long as I can do it, okay, 100 notebooks takes—

Sello: But the expenses are covered.

Gibbons: The expenses are covered. They pay for the expenses. I don't give it to them. I charge them. I send them a bill saying here's the printing expense, here's the mailing expense, here's the postage, and that's what you have to pay me. I say in advance that's what it is. Well, it's a lot less than a dollar per student because I'm not training anybody. Half of that dollar per student was in training.

Sello: You're just exposing them, right?

Gibbons: Well, but I know they're not doing as well as they could either because they're not training people to do it, but it's a completely different application of the principles of video learning and to move ahead to 2012, my view of this online education stuff just computer based springing up all over everywhere with 160,000 students taking one class at Stanford, I think I know how to do that class really well, but what you got to do is you got to collect students in a small group. You got to use the principles that we know and you got to let them stop the tape rather than have the lecture. They chunk it into five minute chunks because they decided five minute chunks are right. We knew five minute chunks were right 15 years before this because that’s how often students stop the tape. But now it’s the lecture stopping it and saying here are the questions you need to answer. It’s not the students stopping it two and a half minutes through saying, “Hey wait a minute.” So even inside five minutes it’s the lecturer deciding, not the student. I know that if you can collect students in a group and have a facilitator or graduate student facilitate their learning, they won’t stop it at the same places that the lecturer stops it and they might actually like for the lecturing chunks to be ten minutes than five depending on the subject, but you don’t get that choice. So I’m trying to get some experiments going like this, but universities in general are so captured with online education that—

Sello: And with enormous classes.

Gibbons: Enormous classes and the fact that hey, of this 160,000 students, 22,000 of them did well on the final. Why is that good enough? And so they did well on the final. Okay, can they actually use it? They did well on the final. That’s all you know. Well, they learned it the same way as they would’ve in class, let’s say, but what happened to the other 140,000 of them? Well, a lot of it’s explanations. When you start getting a lot of explanations and excuses you think something might not be right here. So we’ll talk a little bit about how we started working on ion implantation and what resulted. I was on a sabbatical. We had a sabbatical leave in Denmark and the person that had arranged it for me picked up us and our family at the Copenhagen airport and was taking us out to the home that we had rented and about a third of the way out there he gets a call from one of his—this is an applied physics faculty member at the university. He gets a call from one of his friends who’s a physics faculty member in Aarhus out on the peninsula of land that sticks up from Germany and until then if the physics establishment said, “We need to do this,” the Danish parliament did it because Niels Bohr had said science is good and physics in particular is good for Denmark. As long as he was around or his students, all they had to do was say, “Well, here’s what we want to do,” and they’d do it.

Sello: And he was a physical chemist.

Gibbons: Well, he may have been. That’s good. I didn’t know that, but not he may have been. I guess he was, but this guy calls up and says, “Now the parliament has asked us a question which is this new accelerator that you want to build”—it was a 600-kilovolt heavy ion accelerator. That means not electrons and protons, but things like you might like phosphorus. So he calls up and my friend gets out of the car and he sticks his head back after he’s listened to this and he says, “So you got any ideas about what you could do with a 600-kilovolt accelerator?” because his friend has said, “You’re bringing an American. Ask him. Is there anything he thinks he can do with this?” So I said, “Well, can you implant phosphorus ions?” and so he picks up the phone, he says, “Phosphorus?” and the guy says, “If that’s what he wants, that’s what we’ll do.” So we built in Copenhagen in the university labs, we built an end station to bolt onto knowing the dimensions to bolt onto the accelerator that was then being built in Aarhus and after we had our project done and they had theirs done, we took our machine over there, bolted it on the accelerator, and implanted phosphorus ions into a P type crystal. We knew we would need to anneal them so we had actually a hot end station so that as they came in they would be annealed. We thought if we destroy the crystal structure as badly as they will if they got the whole dose, we’ll never make it work. So we started off with heated end stations.

Sello: And you had one of these at Stanford.

Gibbons: We built it. No, no, no. I did this—

Sello: Before the heated station.

Gibbons: This is 1963 when I’m on sabbatical, so we started doing ion implantation in Denmark of PN junctions. So when I come back to Stanford in September ’64, I start hiring students to build an ion implantation machine that would be capable of doing all the common dopants for semiconductors. So that’s the machine that you saw.

Sello: That’s the one I saw.

Gibbons: And it’s the one that appeared on the IEEE cover sometime after that, but so we launched ion implantation based on an absolute coincidence. I had not gone to Denmark to study ion implantation. I had no idea about that. So it’s one of those kind of interesting things, right? Where somebody you show up—

Sello: Serendipity.

Gibbons: Serendipity. Be in the right place and so that’s how we started and then because we were device guys, we focused entirely on building semiconductor devices. There were other places. Caltech had somebody to start working on it some, but they weren’t working on devices. They were working on scattering physics and all that other kind of stuff. Plenty of good work, plenty of necessary work for the field to develop, but we were kind of the device leaders. So we started improving our technologies and building a lot of different kinds of devices and we were not lucky enough to do the threshold shifting implant that finally got everybody to—

Sello: You started with the basic three-five compounds, three-five atoms too.

Gibbons: Yeah, the doping atoms. We were doing—the things that you would usually diffuse, we wouldn’t touch a diffusion furnace except for annealing. We learned that you could do the entire implant and then anneal—

Sello: Because I remember looking for the diffusion furnace and I didn’t see it, but you showed me the annealing furnace.

Gibbons: Yeah. You have an annealing furnace instead and it’s much smaller and it anneals very quickly, so you don’t have something—you’re not very careful about how you insert stuff because you’re not worried about—you’re not going to get wafer warppage if you control your—it’s not a long cycle. So what happened was over a period of a decade and a half I probably had 20 PhD students who learned the technology, developed it, used it for a large variety of different device applications, and then leaving went to universities and companies and started doing ion implantation.

Sello: And was Doug Fairbairn one of these students that you had?

Gibbons: Doug wasn’t—yeah, well, he was there. He wasn’t my PhD student, but—

Sello: Okay. He took ion implant courses. Yeah.

Gibbons: Yeah, right. But Stanford started developing this stuff and mostly as lab courses, but we did—Stanford started buying machines too, right? So when Jim Meindl in his IC lab said, “Look, I need to use a machine that’s like the one that’s going to be used in industry,” another Stanford thing to do. If you’re going to do something and now they’re industrial machines, buy those.

Sello: Who was building them, Jim?

Gibbons: Excuse me?

Sello: Who was building them?

Gibbons: A company called Extrion. Actually they bought a Danish company in order to do that.

Sello: Yeah. There was a big flap I remember.

Gibbons: I think you all bought devices from Extrion. Varian eventually bought Extrion rather than compete with—

Sello: And for a while there was competition in the newspapers about who invented things.

Gibbons: Of course. Success has a lot of fathers and they all do make their contribution to it. What we did was use the kind of equipment that you build in a university laboratory; it's just like Cambridge all those many years ago. Well, I got to build this and I got to build this and I got to put them together and it's the way you do things when you're starting and so but once you get started and you've got a good machine then you can begin to apply it to lots of different things without having to change the machine or buy an industrial machine. So Gordon never would've been wise to put what we had in his production line, but when it got thoroughly established and safety fully—

Sello: And the safety factors were understood, yes.

Gibbons: Yeah, so but it's amusing that it's the only way to dope now. I mean there's no circuit that doesn't have many repetition of this process with different conditions. The other thing you got to do is you got to anneal and that led to a different line of work. We started annealing in furnaces. Then we decided to use CW scanning lasers, much faster, and that led us to a technology that's called rapid thermal annealing because—and that I had three students each of which left to start a company in rapid thermal annealing, so they were all competing with each other, but the last one, we had designed a system that we made a company around and it was not just to anneal, but when you learn how to anneal well, if you flow gases that will react, you could grow oxide layers very thin. You can also, because you've got your substrate in there to start, you can clean it with hydrogen and so on at temperature—

Sello: And you need those—

Gibbons: —so you get a very clean substrate with no defects on it—

Sello: And extremely thin gates.

Gibbons: —then you grow perfect epitaxy. I mean really perfect. When you look at that junction between the grown layer and the substrate, there's no normal epitaxial process that will give you a perfect interface. This one does and the way you know is if you make a device there its IV characteristics—

Sello: Are shot, yeah.

Gibbons: —are exponential over 11 decades. You can't do that with any defects at that surface. So we were able to grow defect-free surface, defect-free films very thin just by how long you left it there and the temperature, and then we could grow on top of that an oxide. So we could grow a gate stack, a substrate, an oxide, and a polysilicon top and then you could do the implants to implant the gate to give it the light resistivity and implant the drain and source and all that. We didn't do that, but the technology was available so people—

Sello: It'd grow into that, yes.

Gibbons: —invented doing these kinds of things. So I think over that 30-year period, Harry, we first developed implantation and then several different forms of rapid thermal processing and finally built this machine and a company that we sold to Applied Materials. Applied several years ago reported one and a half billion in revenues on this machine alone and it generates a disproportionate amount of their profit if you look at the revenue and the profit associated with it. It was then a disproportionate profit. So the engineering community has recognized this work, these two things as being foundational for the current state of semiconductor technology, which has been a very pleasant thing for me and my students and various of us have received awards for it and all that kind of stuff. But that's what I wanted to do at Stanford was do really good teaching and really good research and make it be as meaningful as it could and we were just so lucky to hit two of those. It was a lot of serendipity.

Sello: The serendipitous trip to Denmark.

Gibbons: That started the implantation and the annealing was started by a former graduate student of mine and he actually said, "Let's don't use furnaces. Let's use scanning lasers," and I thought, "Hey, that's a good idea. So why don't you go try it?" This often happens. A PhD student, you say something about it and he'll say, "Oh yeah, I'm going to go do this instead."

Sello: Right. He wants to be different.

Gibbons: So actually that's where it started. It started when we were trying to think of a different way of doing annealing and it ended up being eventually a different way of growing thin films and a piece of equipment that's universal. So there are a lot of changes and that's usual for research programs. Some student says, "I want to"—we start here, bring them in the lab, get them accustomed to it and then he'll say, "Yeah, but I want to do this." So fine. Go do it. I don't need for everybody to work in this area that we're in and somebody will look at that and say, "Ah, well, then I'll go over here." So all this stuff develops with students getting ideas and it's critical to their PhD education that this happens and when they go out then they're really well educated for doing what they're going to be doing because they know—

Sello: Do you get more good teachers this way too?

Gibbons: Excuse me?

Sello: Do you get more good teachers this way—

Gibbons: I don't know how many of them, but a fair number of them have gone to universities and do have spectacular records as teachers. My second PhD student went to University of Arizona. The third one went to University of Washington. Number six or seven went to Princeton. MIT never did get in it, but it was what the solid state lab could do. That was basic solid state lab stuff to do. Physics and technology of fabrication. The IC lab would take advantage of it and the CIS would take advantage of it, but my home was always where I started. It was in the solid state lab in the physics and technology of semiconductors. So the technologies were always related to that, but when I was asked to be dean I thought, "Why would I ever want to do that?" I mean I've got terrific students. I've got these interesting contracts. I've got a lot of interest from industry in this kind of thing and there are plenty of new problems for us to solve, but my wife said, "No, Jim. It's your civic duty." So she was responsible for my coming to Stanford because I said, "Honey, what should we do?" and she says, "Well—

Sello: Get out of Texas.

Gibbons: —let's try a couple years at Stanford. If you don't like it, we'll go back to Bell Labs if they'll still have you."

Sello: My advice would've been get out of Texas.

Gibbons: Well, we never did want to go to Texas because I had had enough of Texas when I left high school, so she's actually the cause of our coming to Stanford and then she also persuaded me, "You should be the dean. You don't need to keep doing what you're doing."

Sello: Maybe we can sort of taper down. There's no reason we can't think of a reason for you to come back. Let me just ask you do you still get a kick out of and how do you satisfy it to train more teachers?

Gibbons: Well, I can't—

Sello: Is that part of the ballgame anymore?

Gibbons: No, not for me. I wish it were. I would like to work with the school of education to say here’s what I know about this process and how to teach teachers out there in the field how to teach the science, still a major issue.

Sello: Even master’s graduate science at that level.

Gibbons: Yeah, or fifth grade science. So we’ve done a lot of work in that area. We’ve been very successful, but the system rolls on the way it rolls on and it takes a larger effort and somebody’s got to pay for it and meantime the schools have their own needs and they say, well, this isn’t one of them.

Sello: Do you mind me asking a personal question? Then we can close on this, whether you include it in the write-up or not. How do you feel about cloning more Jim Gibbons?

Gibbons: I don’t think the world needs more. I think the world needs people to be who they are and to be as creative and productive as they can be and they will bring something that is special to the world and unique to them, or if not unique, essentially unique. You have, everybody else has, so I’m not a big cloning fan.

Sello: Well, I mean that in the sense of stimulation of not just science teachers, but professorial teachers who can carry on some of the principles that you’ve uncovered.

Gibbons: Well, everybody wants to do it in a way that’s best for them and there’s always some reticence in doing what somebody else has done unless you can add something to it. Now if you’re back in the world where there’s only lectures, then that’s where you make your contribution. It’s in the content you put in the lecture, but if you’re trying to make great teachers, I’ll tell you what we did at Stanford as soon as I came in the dean’s office to improve the quality of teaching across the school of engineering. I said, “Okay, teaching and research are going to be equal partners in your progress toward tenure and I know there are plenty of ways for us to measure the quality of your research, through peer-reviewed papers and citation indices and all that kind of thing, but we’re going to measure your teaching and here’s how we’re going to do it. We’re going to survey the students every quarter for every course and we’re going to find out what they think.” Now we didn’t think of that uniquely. There were organizations, engineering school student organizations that already did that, so I said we’ll just use these tests. Well, some of the faculty’s response to that was, “Well, how do they know how good a teacher I am? They won’t know that for five years when they realize how well I taught them.”

Sello: You can’t count the companies that they’ve started.

Gibbons: So I said, “No, if the students don’t like what you’re doing then it can’t be good teaching at this place. They got to learn and if they do they’ll give you a good report and if they’re not, you won’t be so good. But if you want to use some other way for me to measure your teaching, okay, but I’m going to measure it every year and if you’re not in the top half of the distribution, you’re not going to earn tenure.” So then my colleagues are saying, “Jim, duh. Not everybody can be in the top half of the distribution.” I said, “The bottom half of this teaching distribution is so bad that if that’s where you are, you’re not going to earn tenure as long as I am dean.” People actually went to the provost and said, “This guy’s crazy. You can’t do that,” and the provost said, “Well, we’ll see how it works and I’ll go with him until—

Sello: Until you see otherwise.

Gibbons: —until you see otherwise.” The quality of teaching, when I turned down my first high-quality researcher for lousy teaching, didn’t promote him to tenure, all of a sudden people knew I was serious about it. From that point, teaching took off and if you want to look at the global result of this, Stanford is now regarded as one of the best for the school of engineering teaching institutions because this process continues to go on and there’s a huge premium placed and value placed on teaching including a significant part of next year’s salary. What you want faculty to be are people who spend the vast majority of their time on their teaching and on their research and not messing around in committees and not running off to Washington or whatever they need to do, they need to do because there are social responsibilities and field responsibilities that they have, but fundamentally their job is to do high-quality teaching and research at the university and that’s what you want to pay them for and the rest of us are just supportive of that. Everybody thinks, “Oh the dean is the leader.” I’m trying to just support the faculty and bring in new faculty that can help us grow in directions that we wouldn’t otherwise grow. I could talk about that someday when we’re talking about the dean, what I did as dean, but one of the things was improve the quality of teaching. As a result of that, Stanford rose in the yearly rankings of schools of engineering. We always were in the top five or six. They were always the same, but several years after, in the next survey after I became dean, we were number one by a thousandth of a point over MIT and ever since then it’s been there’s no difference. There’s no difference between Stanford, MIT, and Berkeley and those three are all at the top. There’s a little gap until you get to the next two. One of them is Caltech, but that’s because it’s not primarily an engineering school and this is personal judgment, and one of them is University of Illinois, your alma mater. Michigan is in that group and several others, but so there’s not a lot. They’re all really, really good schools and they’re different.

Sello: So you wouldn’t object to my personal conclusion as a closing statement that the question mark that needs to be answered is how to measure the quality of teaching?

Gibbons: That is something that faculty—yes.

Sello: Not just how to improve—see, you make out a measure—

Gibbons: If you can't measure it, you can't improve it.

Sello: Exactly. So you'll buy off on that—

Gibbons: And I chose a student measurement and after we'd done it long enough, a few years, everybody said this is a perfectly satisfactory measurement. You let the students decide. Now they've got to spend the effort to learn the course and as I said, teachers will get very different reviews if they are teaching a TVI course than they will on campus, so that's another amusing little thing.

Sello: Of course and you can play on that.

Gibbons: You can absolutely play on that, but if you ask the students, these 160,000 students that took this computer science course to do teaching surveys, most of them will say—the ones that did well will say, "Hey, it was great." The ones that didn't do well say, "Well, I just did it—

Sello: It was crummy.

Gibbons: —because it's a Stanford course." They won't—

Sello: A Stanford requirement.

Gibbons: Stanford didn't even require it. They just took it. The large fraction of those people didn't get credit for it and that's not an issue. You say, "Hey, here it is. Learn it if you want to," but that isn't—if you want to teach it as well as you can using that format for its dissemination, I still want to separate dissemination from learning and say okay, if this is my dissemination device it may not be the world's greatest for learning, but the lectures were pretty good, right? Whereas this stuff chunked and all that kind of stuff, you've got to say let's think a little bit about when you want to chunk and all the rest of that kind of thing and who you're serving and how you're going to make sure that each one of those guys learns as well as he can. I know how to do a piece of this which is—we've already done this at some. You end up with a group of learners who are at their workstations, wherever they are, and a lecture's going on and it's on their workstation and when anybody asks a question, all those guys, all their pictures because they're sent back to the head end of the system—all their pictures appear around the principle where the tape was stopped and the tutor's down here and the frame around the guy that asked the question is flashing, so you ask this guy, "So what's your question?" and then you engage this group in trying to answer it. So you can do this on a distributed basis with people that could be anywhere. So there's a lot there.

Sello: And who could feel that they’re contributing something by asking a question.

Gibbons: Absolutely, and learn from it even though they are not in a collective classroom.

END OF INTERVIEW

