

INDUSTRY'S VOICE

Can We Make Progress in (System Administration) Education?

By Mark Burgess

A few years ago, I struck up a conversation with a woman at a cafe in San Jose, Silicon Valley, and she asked me what I did. Having been a physicist, then a computer scientist, and leaving a hard-won university professorship in computer science to start a company engaging with diverse areas of the business world, writing a popular science book, some music, and finally leaving company to write a series of abstruse theoretical papers about the functional semantics of space and time, I really had no idea how to even begin to answer her question. I wasn't even sure which country I was in. I gave her my card, and she emailed me some days later. "You're a teacher," she said. I was not expecting that, but I decided that it was a good answer!

My Teaching Transformation

Looking back over the years, I've spent a lot of my life in teaching, both in industry and academia. It began at university. I taught undergraduate tutorials as a graduate student, then took a summer job at an English secondary school, teaching teenagers science. After writing an early book on C programming, I taught C programming to Acorn computers (who later became ARM) and its clients in the late 80s, at the dawn of the 16-bit microcomputer era. After postdoc'ing, I taught physics, maths, and then computing to undergraduates at University College in Oslo. Finally, after 10 years as a lecturer, I started postdoctoral programmes in Network and System Administration, and had a go with graduate students, too. I left the university, looking to escape from its trials and limitations, and began to educate industry in the possibilities of applying the fruits of what I'd learned about IT infrastructure. The vehicle this time was what industry charmingly calls "productized innovation." So, however I see myself in the mirror, the title of teacher seems to be a fair cop, and I can even claim above-average experience.

Today, I have become a different kind of teacher: a relatively public figure, writer, and advisor. I advise the smallest and the largest IT companies on the planet about technology and self-reliant infrastructure, including the use of techniques like "AI," now very much in vogue. These companies span from the far East to the far West, where cultures differ enormously. When I began, I imagined I might be helping to push the boundaries of knowledge, developing new ideas, but actually the work has always been mainly about explaining the most basic notions, or points of departure. The first lesson of teaching is: everything is obvious once you know how, and nothing is obvious until you do.

So, like Joni Mitchell, I've looked at life (and clouds) from both sides now. Business and academia are two very different worlds, but each are facing the same kinds of problems. In IT, industry is winning.

I am a kind of consultant, but I am not a hired gun. In all of these endeavours, it has been important to maintain what one might call a code of ethics, or set of principles so as not to force-feed answers which I claim to know or which I think they want to hear, but rather try to help the people in these organizations to prosper by showing them what the actual questions may be, so that they might find the answers for themselves. That is inevitably shaped and coloured by my own thinking, but if I do the job well, that is only the disposable delivery mechanism for valuable content.

There are aspects of academia that are just like business, thanks to management culture. As an academic, one is encouraged to feed students simple commodity answers by government, as if there were a standard curriculum for life. This is a cheap approach to delivering the service of education. However, one-way delivery does not support continuous improvement, but the product may have bugs and defective behaviour. The short term costs are low, but the Return on Investment (ROI) may also be low. It is the application of commodity economics. Premium service options might include personal tutorials, individual attention, feedback, and the development of individually tailored

outcomes. Obviously the premium product is harder to mass produce, so it will cost more. But is the customer willing to pay? It's a race to the bottom.

This is all cheesy economic language used by business, but I would put it differently. I like to repeat a slogan that I wholeheartedly believe in: good answers are usually short-lived and contextual, but good questions last a lifetime. Questions stimulate thought, and they are always an opportunity to think anew, bringing new insight at best, and training the thinking muscles at worst. The need for deep thinking has never been more apparent than in system administration, where “how to” recipes and “best practices” dominate over general analysis. For years I have tried to understand why this is.

There Is Nothing More Theoretical Than Best Practice

In 1998, I was asked by an editor at John Wiley & Sons if I would write a textbook about system administration, based on a new course I was developing for the college in Oslo. At the time, Evi Nemeth's *UNIX System Administration Handbook*, and Aileen Frisch's *Essential System Administration* were the state of the art practitioner guides for UNIX. Their focus was how to get things done on the diverse menagerie of Unices of the day. I wanted to do something complementary: focus on unifying and long-lasting principles rather than document the rapidly changing diversity. Moreover, I wanted to unify Networking with Systems (what today we would call “server” admin), which had radically different approaches to management, so naturally my book was called *Principles of Network and System Administration*. The book has been (by academic standards) only moderately successful in terms of sales, but fell far short of the popularity of the practitioner and experiential guides. It received excellent reviews and vehemently hostile reviews, polarizing readers like much of the other work I have done. I wrote a follow-up book for a graduate course called *Analytical Network and Systems Administration*, which people told me was “too hard—you should just give us the answer.” I have been told “dumb it down” more times than I care to count by colleagues on both sides of the academic divide, but never by students, who are happy to be lifted up. This is a paradox. Students are hungry for knowledge, but are being sold cheap commodities by teachers?

Over time, those two books on system administration have made only a tiny impact on the world. They are not considered to be the “cool books” in the field, and even educators have largely rejected them in favour of books written by practitioners for practitioners. Teachers of system administration appear to want to pass on an experience: the same experience they had of being a system administrator, without questioning if there might be something better. System administration talks extensively about “best practices,” though practitioners will argue fiercely about which practices are indeed the best ones. This is a game of conquest (oneupmanship) rather than of discovery. The unspoken rule could be that system administrators have to figure out knowledge amongst themselves, within the culture of tribal practice. Outsiders are not really welcome. When I was practicing system administration directly, I felt this too. More recently, I have often felt like an outsider, swimming against this stream.

Modern Tribes Versus Education

Is IT conservative in the face of rapid evolution? Around 2004, I wrote a very different kind of book called *Slogans*, in which I predicted that the ease of direct mobile communication by electronic devices would lead to a rise of tribal behaviours and fragmentation of societal values as people began to bypass their surroundings and speak only with the smaller circles on their speed-dials. Without belabouring the point, I believe we see this happening all around us, from the creeping politics of nationalism to our smartphone and social media contacts. System administrators were amongst the first to have access to these highly directed channels of communications, and it could be that this helped in the tribalization of their culture. It is no surprise that a group of former underdogs would resent outsiders, especially if it tried to peddle an imposed form of education. As one of the architects of an attempted certification programme around the turn of the millennium, I can attest that even insiders who tried to formalize training were met with scepticism.

Over the years, I have received both great enthusiasm and pretty ugly hate-mail from industry practitioners for pursuing my ideas. In his excellent book *Guns, Germs, and Steel*, Jared Diamond explains how human progress spread throughout the world, and why some countries or regions greatly outpacing others. World reaching empires

grew along side isolated tribes who never rose above primitive settlements. Jared points out that one can never really know whether tools, ideas, and innovation will spread (pay attention sales managers); some cultures are simply resistant to change, for cultural, ideological, or religious reasons. Some cultures live in abject poverty rather than accept modernization. After 25 years of interacting with the world of IT, I conclude that change has not been widely forthcoming because of both poor communication skills and cultural inertia.

In a tribal world, people look a leader for guidance. Today's role models for IT are the technology startups who pour millions of invested dollars into marketing campaigns to seduce IT practitioners. Open source commercialization has become like a major league of fan organizations masquerading as technology companies, each with their own private conference and merchandising. Business has hacked the IT community brilliantly. What could universities possibly do to compete with this big money? Universities have, in a sense, been hacked too, as they accept the popular tools and in the interests of "industry relevance." Materialism has bought tribal allegiance. Only an even more powerful allegiance could overpower this tradition within closed empires, and bring about changes like the cloud services: the rise of Google, Amazon, and the Internet's cool empires dazzle with their full-spectrum technology development and social impact.

Ivory Wombs

The point of academia is to distance itself from the day to day struggle in order to see the world through a wider lens, and then pass back what it has learnt. But what if no one is listening? Should academia simply be one of the crowd? If deep thought is valuable, why, then, is a principled i.e. "academic" approach to system administration consistently dismissed, in favour of a populist practical approach, even by teachers and academics? Do we have nothing to learn by stepping back? I think there are two plausible answers here.

The first comes from the deeply tribal, gamified culture of those drawn to IT. IT tribes identify with their work, their tools, and they like to ascend through the levels of the game by personal merit. In the 1990s, System Administration was considered an underdog in IT. Its special skills were not recognized at all by academia, they had to be won by hard experience. This fuelled a hero culture, with special interest groups and conferences deepening the inward looking. Having been the underdog, allegiances are naturally pointed inwards. Today's open source projects have continued this, tribalizing users into fiercely loyal followings. Which team do you support? Linux or FreeBSD? OpenStack or CloudStack? Puppet or Chef? The idea that universities might steal legitimacy, with an impartial (perhaps imperial) standardized curriculum, attacked this culture. A book written without attaching to an accepted tribal brand was not real knowledge from the horses mouth. As business became the primary employer of IT workers, this conflict between self-centric IT culture and the outward-looking needs of employers became an very public issue, called DevOps. It has tried to rein in moody individuals to become the service-minded collaborators that the world of commerce needs. To reach this, practitioners need to feel empathy for their users, like teachers for students. Not just pushing facts into a repository, but building a trusted relationship.

The second reason for failing to make an impact was related to a dilution of expertise accompanying the Internet's Big Bang. With the new millennium, e-commerce exploded onto the world with the World Wide Web, leading to a thousand-fold growth in the IT infrastructure over a decade. The older grey-beard generation of experts was diluted by the youthful if inexperienced enthusiasm of a new generation, learning by the seat of their pants. Many university students abandoned studies altogether for the offer of highly paid jobs based on only a minimum of skill. On-the-job training replaced education, for a while, and the industry never quite recovered from this skilled labour shortage. Many job tasks have been automated away, many systems completely reinvented without even knowing what came before, all in order to scale the knowledge deficit. Much of the knowledge of a generation was obscured and had to be rediscovered. When the tooling changes faster than you can publish a book, what is the point of trying to formalize? Google and Amazon (with more foresight than universities) took the unique approach of vacuuming up all the PhDs, but they bottled all the research activities in IT infrastructure behind closed doors, publishing and sharing their results only five years or more after filing for patents. This concentration of expertise resulted in the shift to "cloud" or infrastructure sold as a service. The problem of the tribal system administrator was bypassed, but the technical difficulties were just repackaged and pushed back onto users through APIs.

A Role for Universities? (Long-Term Thinking)

Universities are partly to blame for what I would call a serious lack of preparedness for the challenges of industry. As the custodians of society's knowledge, they ought to project a wider and deeper view. I am not talking about technology skills. Political pressures force educational institutions to teach what it thinks industry needs. So they look to the past, rather than leading the way or even looking ahead where industry is looking. Political influences have tried to apply market economics to education, making them conservative. Studies last year probably showed that 8 out of 10 businesses used Oracle databases; but is that the future? Statistics like these distort the view of our industry by focusing on the long tail of legacy rather than on the ripened seeds of change. Legacy technology changes much too slowly for the rapid evolution of IT. University curricula take years to adapt and approve, and teachers are already worked to the bone, leaving best practice courses hopelessly outdated unless they can seek a new mandate.

Where are the curricula about obvious long-lasting principles like system resilience, and scalable architectures taught? How about business alignment? Software developers today come to work for Internet giants believing that they can design software on a PC or laptop and a magic load balancer will elastically scale their application to a global market. When a system fails to behave well, our industry has no better answer than to call it a "bug" and pass the buck for someone to figure out the answer by random testing.

Across the industry, I see engineers following patterns designed for a different era, captured and bottled in training and certification programmes, and taught beyond their usefulness. Instead of asking hard questions, I see university programmes copying certification procedures with a certain righteousness, because who are they to abandon tribal ways? Surely industry knows best. Many of these patterns were long since abandoned by the likes of Google and Amazon, but are still very much the state of the art for industry practitioners.

What Industry Wants Is Not Life-Long Learning (Short-Term Thinking)

The knowledge gap in IT has allowed a few well-known Internet giants to go far beyond the realm of coursework provided by university educations. This has given them cult status. They even make universities (apart from Stanford and Berkeley) appear slightly foolish. The large data centres have become like the Large Hadron Colliders of IT—privileged environments that probe the very edge of a high-energy universe. Bachelor degrees lie far behind what began by necessity and became proprietary knowledge in Silicon Valley and Seattle. This trend weakens academia's credibility, and it can do little to compete.

What seems ironic is that many of the lessons relearned by datacentre engineers were, in fact, predictable by the kind of theory I tried to introduce into the field, and perhaps this was how problems were solved somewhere deep inside the belly of Google; but, the majority of industry and academia is failing in its responsibility to look in depth or ahead. We are used to waiting for a faster CPU to fix the bottlenecks and paper over the design issues by brute force. There is nothing harder to change than culture.

So what does industry want from students? In the language of business, business wants "people who can deliver." The language sounds as cheesy to academics as academic language sounds trite to business. The divide in communication and culture is as large as ever, even as topics like continuous delivery (actually the work of two science graduates), are directly analogous to the scientific method. Employers are looking for maturity and responsibility, enthusiasm, and an ability to work towards a goal, rather than cool kids with "mad skills." Business is mainly about execution of a fixed and conservative plan. They are happy to pay to make problems go away because it is a matter of survival. In IT culture, on the other hand, tribal warriors will happily work a hundred hours, unpaid, to avoid paying a penny to business, because of a distorted sense of gaming morality. (Richard Stallman was wrong. It is not about free speech anymore; it is about free beer.) The zeitgeist of DevOps rose to remind IT tribes that their self-inflicted tribalism can only be supported if someone makes the money to pay them in the first place. A respect for employers and employment could be taught. Employees need to cooperate, not only game their environments for their own amusement (even arguing it to be in the best interests of others). University does not seem to explain these economic realities of business to students.

The idea of life-long learning came out of schools and universities as a social concern. It is not a part of business ethics in a majority of firms. Business always waits until it is too late to innovate. Business thinks in short-term returns, not in long-term social prosperity. If you want to actually innovate, go and start a new company and hire new people, or buy someone else's company! What business wants is a strong work ethic and the ability to apply canned knowledge quickly and methodically to new sales opportunities. It also wants people who can explain what they have done in Powerpoint bullets of one syllable, so that they can ask for money from investors who are not experts. Universities are naive about these needs, and about teaching students relevant skills. Business does not care so much for the systematic, it prefers quick fixes (often to its detriment). It wants quality as long as this does not interfere with "time to market." Initiatives like continuous delivery, DevOps, and agile also take issue with these habits, but it has taken years of evangelism by a few prophets to make a small dent on industry practices.

Rebuilding Trust

What academics apparently ignore about business is that business works almost entirely by forming trusted relationships—skills are merely a means to an end. Skills are the icing on a pretty ordinary cake of human interaction. It took me a few years to see through MBA preaching about matrix organizations and customer satisfaction to what was really going on in business. Ultimately business is about trust. And both business and academia feel that the other has let it down.

Can something be done? Can trust be restored? The alumni of the elite universities, especially in Silicon Valley, are also tribal and naturally favour their own institutions and build relationships. If other educational providers are going to hack IT culture to educate and win trust (rather than merely train in obvious traditions), they need to recognize IT behaviours and adapt to its tribal ways too, forging their own strong identity. Teachers could show strength by bridging the ever widening gap between questions and answers, analysis and process. Business needs employees willing to see more than technology: employees who are willing to and who want to help others, not only win points in their own meritocracy. But they also need to prepare students for the end of this game, and the beginning of the next one.

At the time of this writing, there is a major discussion brewing about the future of work, the "next economy" and the coming of automation (the robots). All hype aside, a major shift is indeed coming that will shake the very foundations of our industrial society, changing once again the meaning of our lives. We will no longer be the machine of production, defined by our work. Commoditized dinners are replacing gourmet cuisine in technology as well as in fast food. This is the first step to a greater reliance on automation. We sacrifice uniqueness of systems for scaling to mass production. This too will change again in the future, as we enter the more automated era, and are able to focus on special needs once again. We will look back with amusement at the things that humans did manually, and how we suffered through the one-size-fits-all era of early cloud technologies. There will be a new market in "artisan system design" for smaller scale enterprises (think macciato, cortado, and frappuchino systems). New skills will emerge, but they will be more service oriented.

The reality is that the basic skills of a society do not change as much as appearances would suggest, but attitudes do. But we are limited and so new offerings tend to be like old offerings, only slightly modified. It may take many generations to get from hunting and gathering to hydroponic farming, or from plugging motherboards to gleaming cloud datacentres, from caterpillar to butterfly. The core may be the same, but the face of it is quite different and the effect on jobs can be large.

Universities could help to teach students about these challenges. What happens today is that academics still set aside principles of educating, and fall back to "skill training," imitating the industry practice of "ask no questions, learn the skill" for the present but not the future. Many employers look for people who studied humanities and learned IT by themselves, for their wider appreciation of human values. No one can capture the latest and still master the breadth, so narrowly trained graduates end up learning out-of-date tools, and end up reinventing new ones instead of building on past progress. The problem with training for an approach based on human skill is that the future does not hold much hope for this kind of work. Automation and "AI" will erode the need for it over the next few decades. The butterfly will hatch.

Closing the Mines

Some believe that software engineering will be the only skill required in the future. We should simply make everyone computer literate to stay employed. Should we be teaching five year olds programming? We've seen many efforts to expand the boundaries of IT tribes through "learn coding" initiatives. But programming alone is just another basic skill, a language for self-expression, like learning Spanish. How shall we teach new generations what to say? What are the challenges for a future society? If programmers and system administrators are trapped in a world no larger than the size of a screen, then computer programmers are little more than modern coal miners. Their world is narrow and replaceable. They may become tattoo artists, copying imagery imagined only by others and transferring it to a new medium. This too is replaceable by automation. Without the skill to think and question, society will be trapped in a rut, while a consumer growth economy steams on by. Caterpillars may emerge as butterflies, only to find that the world is now underwater.

Education (as opposed to training) is an uncomfortable anomaly in the industrial world. It does not fit the "mold and replicate" model well, so we struggle to scale it. It is about building a relationship to a speciality or a field, and relationships are expensive. Equally, we have not yet learned to fully live along side the surplus of information available to us that could lighten the load. We live in a vending machine age, getting anything we want at the push of a button. This is a world where pattern-repetitive labour stands to be replaced by automation. The ease with which we can access answers makes it difficult for students to appreciate the value of new questions, and knowledge as a relationship (not just a one-night stand). Could a university education still help them?

The business-university gap is not necessarily a bad thing, as long as both sides continue to stare at each other across the wall. Isolation from information is needed for deep thought. Invention, innovation in industry terminology, is a process with two parts: there is the mixing of genes (ideas) and then the a protracted isolated to gestate the germs of idea into a testable prototype. In the USA, academics move freely back and forth between industry and academia. Isolation can be a force for good. In the past, knowledge was isolated into ivory towers in order to give experts time to think and develop. Their separation from the day to day was an advantage. But it was more common for them to be connected to the world beyond out of hours. Today, the culture of business and universities has grown so far apart that their goals are not even aligned. Academia's incentives, twisted by governmental politics, have fuelled competitive hostility for grants between rival researchers, and more of a search for reputation than understanding. Universities look mainly inward, with a different system of values.

Looking Ahead, Choosing a Direction

Teaching (preparing a new generation for a productive and dignified life) is, remarkably, one of the least incentivized pursuits in our societies. We are geared to maintaining a status quo, even as technology punctures the equilibrium. It is itself treated as the kind of commoditized welfare work. That is regrettable, but it is also a natural progression, given the changes in social structure across the developed world. Since the industrial revolution, we have identified our lives (our sense of dignity and purpose) by our work (by our tribes). And our work has been largely repetitive productivity, fuelling a macroeconomics, whose success is measured by growth: "do it fast and do it more" seems to have become the depth of our aspiration.

I have made something like a career out of thinking ahead and playing agent provocateur. One could say that I am still a rogue hunter-gatherer who could never live with a tribe. I have swum against the stream, been tolerated, vilified, and eventually won a kind of endangered species license to be different. The reality is that people hire me, hoping for a quick answer, to bypass their own need to learn and think for themselves. I still refuse to do that, and luckily I have not been fired yet. I am not the only one. This tells me that there is hope. Change happens through persistence and socialization. But teaching, not just disseminating, is important. The relationship is crux of human society.

Our concept of knowledge has changed in the information age, but ultimately knowledge is a relationship, a repeated visitation of something or someone so that we learn to know that something as a friend. We increasingly trust others' experiences and recommendations because there are only so many relationships we can afford. New forms of social knowledge-passing have entered the field. Blogging has become a very important source of learning online. Blogs may

introduce ideas to a popular audience as well as demonstrate specific procedures and practices. They are a supplement to Wikipedia. They bridge a gap between isolated expertise and thought provoking discourse. I can envisage a day when national service draft papers call in retirees to teach younger generations of their experiences. What will be important in the future is how we socialize knowledge, in the new landscape of information and communication.

This sounds nice, but reality intrudes. What I see, everywhere I go, is that lofty ambitions get dialled back to make life easier for students and teachers under pressure. To be a great teacher, one needs to be passionate and singular of purpose. It costs a huge outpouring of emotional energy, which not everyone is willing to give. Goals become eroded as commoditization sets in. Scale that! We get microwave dinners in place of bespoke cuisine. This single idea is the generic challenge for humanity's future economy: to scale service without loss of individuality. After that, it's robots all the way down.

We Are All Industry, and Always Learning

The future of IT and education lies as much in the boardrooms of business as it does in academia. Business and university do not belong together; they serve different roles, but they can work along side. Universities should not expect donations, and business should not expect free labour. Both are usually struggling to make ends meet. Unless industry and academia can both think ahead, in a more societally responsible way, our economy is vulnerable to collapse, as outpaced humans are traded for canned automation, and redundancy brings unemployment, alienating an entire generation who have no plan for their lives.

The cycle of life needs both the quick genetic mixing of ideas and the slower gestation of the prototype, learning by selection on each cycle. We need to make time for education. It doesn't have to be given all up front. It could be embedded in every week of our lives. In IT, industry seems to have taken over many of the roles, leaving learning institutions out in the cold. Schools and universities are now more for the maturation of life skills than for learning and reasoning. But every cyclic process also needs to know history. The memory of what came before (and why) is the only way to become consistently better. History sets a standard.

Universities may well have to adapt to deliver more about the history and philosophy of their field than on the details of tooling, to become the GPS of learning rather than the big data fileserver, because one day all the answers could be old and withered, and only questions will remain.