The Engineer's Dilemma: Innovation in Singapore

By Patrick Lambe

If you look at how Singapore approaches innovation, it looks very much like an engineering problem. Rule-bound, risk-averse Singapore is the problem, and the output we want is more innovation. So being engineers, we have to figure out what new input to the system will produce that output. Simple, right?

So we conduct our measures. We count graduates in higher education, we count the number of patents filed, we count dollars spent on research and development. We set aside budgets for innovation projects.

And as part of our inputs to the resolutely uncreative Singaporean mindset (we suppose), we hold competitions, devise innovation schemes, train people in creative problem solving and idea generation techniques, seek out infallible, easy-to-apply innovation recipes, devise standards and measures for innovation certification, hold umpteen conferences, talk all the time about the need to change mindsets (usually somebody else's), and have innovation fiestas at strictly regulated intervals. Committees sit, look at the numbers, and recommend.

The results are questionable. Of course, it's far too early to expect anything radical, we've only been beating this drum for five years or so. But you get a sense there's an impending air of disenchantment about the whole thing. What would more innovation look like if we had it? Where have all the innovation dollars gone, and what do we have to show for them? Have we done any more than provide free innovation lunches, harass our employees with unspecific demands to do better, and badger our managers with injunctions to take all-too vaguely specified risks?

The engineering approach is precisely our innovation problem. The engineers are part of the problem, not the managers of it. Think about it, the myth of the omnipotent engineer sitting above the stubborn Singaporean box and changing the inputs to influence the outputs is just that – a myth. The engineers, the government, the civil servants, the private sector managers, the workers, are all in the same box together. It's not somebody else's mindset that has to change, we all share in the construction of the mindsets we bat around our society. We are all part of the same problem. We can't throw dollars and will-power at this, like it's a clearly defined problem with specifications. We're all stewing in the same soup.

The authority of the engineering approach is easy to understand. It has been a tremendously powerful approach to some of mankind's most intractable problems over the past 150 years. Think of health and sanitation. While doctors argued for a hundred years over what might be the transmission vectors for deadly disease, the engineers quietly and methodically built sewerage and water supply systems and lengthened human lifespans by thirty to forty years. The engineer identifies a problem, focuses in upon it,

and tries to understand it in practical, measurable terms. The engineer plots a route to a solution, rigourously ironing out the possibility of failure along the way. The engineer scorns theory, and builds things that work. And Singapore is pre-eminently the product of engineering skill. It works.

Small wonder the dominance of the engineering mindset here. If you count the output of the polytechnics, ITE, and the universities in Singapore over the past decade, you very quickly realise that 40-45% of those graduates are trained in some form of engineering. If you extrapolate that backwards to encompass the past thirty-five years, then engineers could well take up a quarter of the entire workforce. Engineers certainly account for a quarter of the Singapore *Who's Who*. If you look at the Cabinet, the picture gets even clearer: three quarters of the Cabinet are trained in maths, science or engineering.

To understand why this might be a problem when it comes to innovation, let's consider the analogy of a game. Golf is an engineer's game. It's a problem-solving game. You have a problem, the hole, and in theory, getting your ball into the hole is entirely calculable: if you can measure the windspeed, the atmospherics, the inclines and friction of the surface, and if you can control the weight, angle and velocity of the swing, you'll solve your problem. It's not by chance that three-quarters of the Cabinet also play golf. Like golf, engineering is above all a problem-solving game. It only works if your innovation environment is one of specifiable problems that you can pin down, locate, and work hard at in a consistent, methodical fashion.

Tennis, by contrast, is a responsive, adaptive, dynamic game. Here, it doesn't matter particularly where the ball goes so long as it stays within the court. The point here is not so much the precision with which the ball is directed, but the addition you make to the direction, angle, spin of the ball as it comes at you. Each player must both respond to the novelties added by the other player, and add something special to the ball when they send it back across the net. The fun of the game is in the ability to respond, adapt, and add something new. It's a much more *playful* game than golf.

Tennis is a far better analogy than golf for our current innovation environment, because it's all about responding to uncertainty. When the problems won't stay still, and when we can't see or define them precisely, the golfing approach won't work. Small wonder we can't be sure what a more innovative Singapore would look like. The need to measure it is an engineer's worry. The tennis player worries more about catching what's coming at us now, and sending it back with a little spice added. It's no accident that Prime Minister Goh Chock Tong's first passion is tennis. Innovation and adaptiveness have been his signature theme for years now.

Singapore's innovation problem is the power of the engineering view. The rules of the innovation game have changed, because the world has changed, but the mindset that sees innovation as a set of definable problem-solving methodologies is powerful by virtue of its success, and it is pervasive in the huge number of people trained in its tenets. Singapore's ability to play with fuzzy, emerging, volatile, ambiguous, interconnected, and complex problems is severely constrained. For that we need imagination, energy and

verve. For that we need more *playful* people. Focus, discipline and methods tried and true are no longer enough. But it's hard to let go, especially when the stakes are so high.

On June 10 2000, a new footbridge across the River Thames in London was opened to great fanfare. Named the Millennium Bridge, it was designed by one of Britain's foremost sculptors, Sir Anthony Caro, a pupil of Henry Moore. It was built by world leader in bridge building, engineering company Arup. A symbol of British innovation for the 21st century, it used a radically new design, and although a suspension bridge, had such a shallow span that when you approached it at night, the concealed lighting in the structure gave the vision of a flat plane of light soaring effortlessly across the river with no visible means of support.

The bridge was closed two days later, amid fears for its safety. When the crowds crossing it had reached a certain density, the bridge had started to sway noticeably from side to side. Now engineers know about swaying bridges. They are religiously taught about the resonant frequency of structures, and they have all seen the graphic footage of the Tacoma Narrows suspension bridge collapse in 1940. At Tacoma Narrows, in Washington State, one windy day, the frequency of the gusts of the wind started to match the natural frequency of the bridge's structure. The gusts of wind reinforced the vibrations of the bridge, and the movements started to amplify. The film of the collapse shows the vast concrete and steel structure literally shaking itself to pieces. Engineers know about such things.

Arup had paid particular attention to vibration. The design of the bridge, and its shallow span, had posed particular engineering challenges to stop it moving. They had worked very hard to make the bridge stiff and steady. This vibration should not have been happening. After the fact, they figured out something they had never anticipated. The average human being walking across a bridge, exerts about 250 Newtons of force vertically with every step. The engineers had taken that into account. But being bipedal, we also have a slight side to side motion when we walk. What the engineers hadn't accounted for, because it seemed negligible, was the 25 Newtons of force we exert laterally. Indeed, this wouldn't have been significant if only the people crossing the bridge hadn't been normal human beings.

Human beings tend to want to go with the flow. If we sense ever so slight a give in a structure, we'll retime our footsteps to coincide with the trough of that motion. Slowly but surely, the hundreds of people crossing the Millennium Bridge were simultaneously recalibrating their footfalls to synchronise with the resonant lateral frequency of the bridge – and when the mass of people reached a critical number, the oscillations became noticeably amplified.

Arup were so excited by this discovery that they coined a new technical term to describe it: *lateral synchronous excitation*. But as much as they liked the phrase, they didn't want the phenomenon. They had to stiffen the bridge, despite the fact that people quite enjoyed the swaying, and despite the views of some experts that there was no danger to the structure or the people crossing it. Because it was not a materials problem but a human

problem, existing algorithms couldn't tell them how much stiffening or extra support they had to put in. They had to count batches of people going across the bridge to calculate the point at which the excitation would begin.

The Millennium Bridge was opened again after its refitting work in early 2002. It doesn't sway any more, the support structures are more visible, and it no longer looks like a flat plane of light soaring effortlessly across the Thames. But it *works.*

Sometimes one wonders what would have happened if the engineers had left the Bridge alone. Even Arup say that it was never really unsafe. Maybe lateral synchronous excitation is more of a gift than the engineers would admit. The engineer's dilemma is a difficult one. Could they have simply left it alone, and allowed the people to play?

Maybe Singapore's innovation challenge isn't an engineering problem after all. If we didn't have the engineers, there would be no bridge. But playful behaviour cannot be engineered any more than innovation can. Maybe the engineers should just step back, stop tinkering with the system and let the bridge sway.

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