An introduction to innovation

Dr Barry Harrowfield

Wool industry consultant

The meaning of innovation

What do we mean by innovation? Innovation carries with it the idea of something new. Innovative people are expected to come up with 'bright ideas', to have a novel way of looking at things, to 'think outside the square'. If a product is seen to be innovative, its design or its function or both is new and improved over that which has previously been available. *That's a great innovation,* we say when confronted with a new and better way of doing things.

Most often, an innovation brings with it a monetary return for the innovator, and that return comes about because a competitive advantage has been gained in the marketplace. Customers want that particular innovation in preference to what has gone before. While innovation often brings a win to somebody, it may also mean somebody else will lose. It is a battle out there.

McKinsey's Richard N Foster notes in his *Innovation: The Attacker's Advantage*:

> *But for me innovation was and still is … a battle in the marketplace between innovators or attackers trying to make money by changing the order of things, and defenders protecting their existing cash flows.*

Innovation and monumental change

A famous example from textile history did actually involve battle. In the early years of the 19th century, textile workers around the English town of Nottingham carried out acts of industrial sabotage against the newly rising factories that used the new power weaving, knitting and textile technologies. The Luddites, as the followers of Ned Ludd were called, were objecting to the demise of their cottage industries, which, while they produced high quality product using well-trained and skilled craftsmen, were no match economically for the new order. Ultimately, the uprising was quelled by force of arms and men were killed, imprisoned, hanged or even transported to Australia.

The words 'ambush' or 'assault' might also be appropriate. In April 1860, a group of businessmen in Sacramento California set up a company to carry light mail to and from St Joseph, Missouri, in the middle of America, a distance of 2000 miles or 3200 kilometres. The venture involved 100 riders and 400 horses. This was the famous Pony Express. In October 1861 the company closed. It had invested $700,000 and was still $200,000 in debt. A major reason for its demise was the opening of the telegraph line between Missouri and California. The venture had been 'dry-gulched' in the language of the Wild West; a monumental technological change was taking place. In time, the subsequent mail and passenger service along the route offered by Wells-Fargo would suffer attack from a new technology, the steam train.

Innovation and incremental change

While examples of groundbreaking innovations come easily to mind, small yet significant change can also be innovative. Each day in industry improvements are made to the way processes are carried out leading to increases in production rate, product quality, waste reduction, and worker convenience, comfort, and health.

Imagine a spinning manager and his or her team seeking to improve the quality of wool yarn. Greater yarn uniformity and fewer thin places are the goals. After some thought and some well controlled trials a combination of improved fibre selection and changes to drawing and spinning frame parameters result in significant improvement in yarn quality. A

plot of Coefficient of Variation (CV) versus Time shows a relatively rapid jump from the old level to the new. In general, the reward continues on through time.

A common feature of this kind of innovation is the very significant benefits gained downstream as a result. Fewer clearing breaks, greater winding efficiency, reduced waste, fewer loom stoppages, reduced fabric mending and increased fabric quality will most likely result from the spinning team's effort. So, while this kind of innovation might be thought of as incremental, the benefit to the whole enterprise may be very significant. This is why effective enterprises encourage the development of awareness by their staff of the whole process, not just the immediate work area. And while the innovation on the spinning floor may not easily be seen in terms of attack and defence, the improved product quality and value for money the company as a whole can offer to its customers as a result may very well be the weapon of attack, which the company uses to increase its market share against competitors.

What examples are there in your area of business where incremental improvement can have or has had important rewards?

The evolution of an innovation

Whether it is monumental or incremental, all innovations follow a similar pattern. There is a new understanding, inspiration, challenge, opportunity or discovery that initiates the whole thing. Almost always, technology will be involved, whether the innovation is a startling new discovery or a novel use or novel combination of existing technologies. There follows an expenditure of effort in developing the new initiative. A period of reward for effort follows and this can be explosive in nature. I've chosen to call this the 'boom' phase. Finally, the reward for effort expended tails off and flattens. In the end it will usually fall away, and this can often be catastrophic as a result of a challenge from another innovation.

The plot of Reward (number of sales, profit, and so on) against Effort (staff hours expended, money invested, and so on) is usually referred to as an S curve. S curves can be used to characterise many areas of human activity, from the progress of a building project to the rise and fall of an empire. They are particularly useful in visualising the evolution of innovations in periods of rapid technological change. While many S curves are a plot of Reward versus Time, it may often be more informative to choose a variable more closely related to the true effort expended. The plot of CV% versus Time in the spinning example referred to earlier may also be seen as an S curve.

A particular class of S curves uses a plot of cash flow against time. An initial promising idea usually needs considerable resources applied to enable it to develop it into a prototype and even more expenditure to push the development through to commercial release. Up to this point there has been no income at all. The cash flow has so far been negative and generally will remain so for a time after product release because of the cost of marketing and product support. If the product is successful, cash flow will become positive and even highly lucrative until competition erodes or eliminates the advantage. This class of S curve therefore has a negative dip to begin with and is sometimes referred to a J curve. Nevertheless the shape is still clearly that of an S.

A good example of an S curves can be obtained by plotting recorded music album sales as Sales versus Time. Here, both vinyl discs and CDs are regarded as albums. The curves for the two types of recording are plotted separately together with their combined sales. Clearly, the CD was seen by the market as a much more desirable product than the vinyl disc and the peak number of CDs sold per annum vastly exceeded that of the vinyl product at its peak. Despite its success, the CD has passed its heyday, the curve suggests.

Where has the innovative attack on the CD come from?

The discontinuity

Foster refers to the period of transition from one innovation to another as a 'discontinuity'. At a discontinuity, the Reward versus Effort curve breaks into two. It is the point at which one technology, design or concept takes over from another. In many cases because the new innovation is able to almost immediately capture the defending technology's market and build upon it, the rewards to the innovator will surpass those of the defender, just as in the case of the CD.

There are a multitude of examples of innovative attack leading to a break or discontinuity with what has happened in the past. The following are some examples.

Defender	**Attacker**
Sword and shield	Bow and arrow
Bow and arrow	Firearms
Wind power	Steam power
Horse power	Internal combustion engine
Cylinder recording	Disc recording
Telegraph	Telephone
Thermionic valve	Transistor
Discrete wired electronic circuits	Integrated circuits
Portable CD player	MP3 player and music downloads
Natural fibres	Synthetic fibres
Denim	Tencel
Wool knitwear	Cotton knits

Incremental and monumental innovation revisited

As a tool in analysing the innovations that will be encountered in this module it is useful to identify in more detail some of the typical characteristics of these two extremes, bearing in mind that most innovations in the textile arena will lie somewhere in between the two.

Sometimes monumental innovation will be identified with research-driven ventures, while the word 'incremental' will be used to describe everyday industrial development. However, both are better seen as part of a continuous spectrum of innovation, and often categorisation will depend on the viewpoint of the observer.

Monumental innovation	**Incremental innovation**
Major paradigm shift in technology	Novel combination of existing technologies or pedestrian change in use of known technology

Initial high risk of failure	Low risk of failure
Technology based on, and continues to require, scientific study at a fundamental level	Little or no new fundamental science needed
Significant R and D costs in both time and money even before product launch	Relatively small development costs
Major negative cash flow as a result of not only R and D costs, but initial marketing costs	Marketing costs likely to be the most important component of relatively small initial negative cash flow
Costly technical support even well into the boom stage and beyond	Little technical support beyond product launch
Potentially very high returns if successful	Generally smaller returns, particularly where innovations are following fashion trends
Lifespan of years, sometimes decades	Shorter lifespan, often within a fashion cycle
Technology used in many product ranges	Directed at a single product range
Triggered by a major innovative attack	Directed at maintaining a mature phase of a major product line
Often seen as the only way to save an enterprise or industry in the mature phase particularly if is under attack.	Often seen as preferable because of the higher number of ventures at lower risk
Any additional criteria?	

The defender's response

How do defenders respond when an attack appears on the horizon?

All too often the defender is caught unawares by the emergence of the new. Often, even when an attack begins, the defender will not take it seriously. However, the defender ignores an attack at their peril. They can choose to take a number of different approaches.

Ignore or deride it

When talking pictures made their appearance there was considerable scepticism in the silent film industry. The new technology wasn't considered by all to be a serious threat; indeed Charlie Chaplin continued to make silent comedies until 1938 when production started on his first talkie, *The Great Dictator*. Said Chaplin, 'The silent picture is a universal means of expression. Talking pictures necessarily have a limited field; they are held down to particular tongues of particular races …'

Defenders may not even be aware that defence is necessary. The traditional business suit looked impregnable until the more casual, 'dressed-down' approach became acceptable in the 1980s. This had serious implications for the wool market because of the high level of wool content in business suits.

Can you think of more examples of the 'ignore or deride' approach?

If you can't beat them, join them

Japanese car manufacturers made huge inroads into the American and world-wide automotive market by designing compact cars that were more economical to purchase and operate, better assembled and designed with the user in mind. Much of this could be attributed to the kind of attention to detail and improvement in process control advocated by Dr J. Edwards Deming. Indeed in 1951, the Japanese Union of Scientists and Engineers inaugurated the Annual Deming Award for Quality Control in his honour. It continues to be a highly coveted award in Japan.

It is worth spending a moment here on the Deming philosophy. Deming saw four essential components in the management of an innovative enterprise:

- systems thinking – all staff should be aware of how their work contributes to the benefit of the customer, not just their own work area
- understanding variation –acquire meaningful data about process and learn how to interpret it properly
- psychology – staff perform better and innovate more creatively if they feel their efforts are adding to the enterprise effort not just their own reward
- knowledge – true knowledge of the underlying cause of the result of change is essential to rational decision-making.

Only by learning from the Japanese was the American industry able to claw its way back into the market.

In 1972, Texas Instruments patented an electronic camera that did not require film, and in 1985 digital imaging was introduced by the animation company Pixar through its Image Computer. The response by Kodak to the digital era was to develop and market aggressively its range of digital cameras and downsize drastically its efforts in photographic film development, production and marketing. Kodak is credited with the invention of pixel-based technology, now known as the digital camera, which it introduced to the market in 1991.

Some of the wool innovations you will be introduced to in this module are the result of acknowledging that the world has changed and that wool interests need to be able to offer to the world's consumers products that are as attractive or even more so than the competition. This is particularly so in the lightweight, next-to-the-skin garment area, and the sport and sport casual markets.

Attack is the best method of defence

As a counterattack against the multitude of competitors in the digital camera field, Kodak not only offers its own cameras but also seeks to exploit the perceived need by consumers to have hard copy photographs. Kodak cameras mate with their EasyShare printer docks to enable home-based production of photographs. This attack also faces competition, with both Sony and Canon offering printer docks for their cameras. It will be interesting to see how hard copy competes with electronic means of display, especially now that mobile phones and other consumer electronic devices such as iPods carry a picture capability, and, of course, personal computers offer both pictorial display and printing capability. To add to the complexity, print shops offer very cheap printing with a quality that probably surpasses that of the home dock. This looks like a battleground with multiple S curves evolving.

The innovator's advantage

Why is the innovative attacker in a much better position?

Innovators often have the advantage of surprise. There is a huge gain to be made by being first and by being fast. Apple has made a real killing with the timely introduction of the iPod, the first of a new technology that has swept away older forms of storing and transporting music. What price now Walkmans and portable CD players? Being the first into the marketplace, Apple has left its competitors in the position of playing 'catch-up'. Apple continues to release upgrades of the iPod, with new physical features and increased storage capacity. It will be interesting to watch the progress of the S curve for the iPod and to speculate about the innovative attacks that may occur in the future.

As an interesting aside, following release of the iPod there was some concern about battery performance and this required rapid and effective remedy. Fortunately for Apple, the problem was quickly fixed. The lesson here is that innovation has to be based on sound and ongoing technical development and support to avoid disappointing or, worse, repelling consumers.

A textile equivalent to the iPod might be the introduction of Polar Fleece by Malden Mills in 1979. Now known as Polartec, because of technical advances made beyond the original product, this polyester-based fleece has revolutionised garments in a host of sport, sport-casual and casual arenas. There are imitators but the reputation and demand for the innovator's product remains strong and Polartec has captured significant sectors, such as the US military, which are likely to be there in the longer term. The defenders were the manufacturers in the warmth-without-weight, breathable, durable and machine-washable clothing market.

Are there any disadvantages or dangers in being an attacker?

The conception of an innovation – the Aha! experience

Where does an innovation come from? What triggers the beginning of an S curve, be it monumental or incremental in nature?

It is valuable to look at how some innovations have arisen in the past.

The integrated circuit – Jack Kilby

In August1958, while employed at Texas Instruments, Jack Kilby invented the idea of assembling electronic components on a chip by successively depositing layers of conducting and semi-conducting materials. This bypassed the need to assemble discrete components like resistors and capacitors to form an electronic circuit. The breakthrough ultimately allowed huge electronic devices to be shrunk to the size of a pinhead and is the basis for all modern consumer products, such as computers, mobile phones, iPods and, indeed, anything else electronic.

The immediate circumstances of the point of invention were that, because he lacked seniority, Jack was unable, like the rest of the company, to take a summer vacation. Working alone, he recalled, 'I was sitting at a desk, probably stayed a little longer than usual. Most of it formed pretty clearly during the course of that day'. Little else seems to be known about the mental processes involved at the time – the actual Aha! moment.

Jack's historical background included an introduction to radio electronics by his father, a time working for a company manufacturing hearing aids using the new transistor

technology invented in 1947, and the silk screen technique of producing ceramic-based circuit boards. Reduction of size was an important goal for hearing aid design.

Composing music – Wolfgang Amadeus Mozart

> *Thoughts crowd into my mind as easily as you could wish. Whence and how do they come? I do not know and I have nothing to do with it. Those which please me I keep in my head and hum them; at least others have told me that I do so. Once I have my theme another melody comes, linking itself with the first one, in accordance with the needs of the composition as a whole. Fragments at last produce the complete work. Then my soul is on fire with inspiration. The work grows; I keep expanding it, conceiving it more and more clearly until I have the entire composition finished in my head though it may be long…"*[3]

While the authenticity of this quote attributed to Mozart in Penrose's *The Emperor's New Mind* is questionable, in an early 1798 biography quoted by Solomon in *Mozart: A Life,* it was reported that Mozart could

> *see the completed work clearly and vividly when it came to him … We rarely find anything corrected or altered in his concerto scores … In his mind the work was already complete before he sat down at his desk.*

In support of this account of Mozart's extraordinary ability is the often reported amazement of witnesses to his ability to improvise at will.

Note the surprise popping-up of ideas ('Thoughts crowd into my mind as easily as you could wish. Whence and how do they come? I do not know…'). The picture emerges of one who received music as dictation from a vast store of creative work taking place in the subconscious mind.

Then there is a selection or shooting down process ('those which please me I keep…').

Mozart had travelled extensively with his father as a child and young man and in an age where there were no means of recording music, had an unparalleled opportunity to listen to a wide range of music and to meet and play with performers and composers. He had also had tuition from his father, an accomplished musician himself, from the time he was a toddler. His mind and motor skills were very well prepared.

The Nike air shoe – Bill Bowerman

Some time in 1959, Bill Bowerman invented his waffle iron-based sole for a running shoe. Bowerman had been the athletics coach at Oregon State University since 1948 and strongly believed that a reduction in weight of running equipment, while preserving durability and functional performance, would greatly improve athletic performance. While at breakfast he was watching his wife prepare waffles and conceived the idea of constructing a sole using a waffle iron to form the cleats. The Waffle Iron Sole was born, and became a signature product for what was to become the Nike Company.

It is interesting how a prepared mind, focused over an extended period on a problem to be solved, made a connection with what at first sight might seem to be unrelated technology.

The structure of DNA – Part of James Watson's account

> *When I got to our still empty office the following morning, I quickly cleared away the papers from my desk top so that I would have a large, flat surface on which to form pairs of bases held*

> *together by hydrogen bonds. When Jerry came in I looked up, saw that it was not Francis, and began shifting the bases in and out of various other pairing possibilities. Suddenly I became aware that an adenine-thyamine pair held together by two hydrogen bonds was identical in shape to a guanine-cytosine pair held together by at least two hydrogen bonds … The question then became whether the A-T and G-C base pairs would easily fit the backbone configuration (two sugar-phosphate helices) devised during the previous two weeks.*[6]

History tells us that they did indeed.

There were many Aha! moments in the DNA story and many researchers contributed significantly to the information base from which Watson and Crick could jump to their structural solution. What is striking is the degree of involvement and identification that those involved brought to the problem. They 'lived' with it. Crick's skills as a physicist interested in protein crystallography complemented Watson's background in biology and genetics in particular. Both benefited from the involvement of Maurice Wilson, another physicist at King's College, London, who had targeted the structure of DNA as his problem in the first place. And the central core of people would have to include Linus Pauling who had elucidated the alpha helical structure for proteins and Rosalind Franklin whose crystallographic work was crucial to unravelling the problem.

This story is an excellent example of a 'melting-pot' of minds at work. It is also an account of the almost feverish popping up of ideas and, like Mozart, shooting them down if they don't fit. Play with models and ideas was also a big part of these innovators' lives.

The Holden Sandman – Holden and Mambo design teams

The Sandman was based on a sketch doodled by a young designer, Adam Smith, in 1997. It drew inspiration from a panel van released in the 70s by Holden, which was also called the Sandman. This vehicle became very popular with the beach/surfing culture. According to Mike Simcoe, CEO of Holden's design team, the project started as a bit of fun but gained momentum when the surf and streetwear company Mambo became involved. The creative director of Mambo, Dare Jennings, pointed to the strong sentimental attachment in Australia to this icon. Staff had either owned one or, in the case of younger members, been conceived in one. Apparently, the design teams got a great creative kick out of the project and had a lot of fun.

The Ford Territory

The Territory was designed to accommodate the need for a 'people mover', which had the driving comfort of a sedan, while meeting the 'aspirational' desires for freedom and travel, off-road capability (even if it would seldom be used), and practicality for the family. The Territory has been very successful in a market where there are a lot of competitors.

Be alert to the issues of design, development, manufacture, marketing and investment risk when we visit the Ford Discovery Centre later in the module. Seek out, if possible, the Aha! experiences and triggers that lie behind the Territory and other Ford Innovations.

How to encourage an Aha! experience

What steps would you take to encourage innovation in your own line of business?

From the above stories, there seem to be some promoters for the Aha! experience:

- a clear perception of the goal of the task at hand

- a good and preferably deep understanding of the theory and technology of the subject areas associated with a problem or opportunity
- a mind that is prepared, not just in the immediate problem area, but more broadly. Experience and knowledge from often seemingly unrelated areas sometimes makes surprising contributions. Developing a wide and deep knowledge, experience and understanding base well outside of one's area of occupation is seen by Stephen Covey as one of the Seven Habits of Highly Successful People. He calls it 'sharpening the saw'
- a focus of attention, not necessarily continuously, but at least over time. A willingness to wrestle with, or even become obsessed with a problem is valuable. Even when conscious thought is not directed to the task at a particular moment, a solution often pops up from the unconscious provided the mind has been engaged with the challenge. Alertness to the possibility of innovative attack, either as an attacker, or a defender, is a good example of focus over time
- interaction with other people and other minds
- a time and place to dream, create and, above all, play
- an element of fun.

Summary– approaching innovation

Here are some questions that can be used to analyse the innovations that will be encountered in the Innovation module.

- What triggered the innovation?
- What is known about the actual Aha! experience?
- How well prepared was the mind of the innovator or innovators?
- Where does the innovation lie on the monumental/incremental scale?
- Where is the innovation now on the S curve?
- What scientific and technological challenges has the innovation faced as it moves through its S curve?
- What is the likely lifetime of the innovation?
- What has been the reward for effort expended? Who has reaped the rewards?
- What threat or threats might the innovation face in the future?
- If the innovation is in its mature phase, what can be done to head off a potential attack?

References

Foster, Richard N., 1986, *The Attacker's Advantage,* Pan Books.

Penrose, Roger, 1989, *The Emperor's New Mind*, Oxford University Press.

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Watson, James D., 1968, *The Double Helix*, Weidenfeld and Nicolson.

Questions

1. The zipper was patented in the middle of the 19th century. It was used in a relatively minor way for rubber boots and tobacco pouches early in the 20th century; however, its first use in textiles was in children's wear and men's trousers in the 1930s.

   Discuss when the zipper became an 'innovation'.

   As a help, visit http://inventors.about.com/library/weekly/aa082497.htm.

2. Can an invention be made with no prior related knowledge? Give examples to support your case (you will gain some points of view on this from several units in this course, in particular, those of Dave Phillips and Tony Turk).

3. Vacuum tube technology to amplify electronic signals became available in the first decade of the 20th century. Can you trace some of the important leaps in knowledge that needed to be gained before the innovative attack by the transistor could be made?

   (If your scientific background is a little shaky you may skip this one, but do a little research and give it a try.)

4. Discuss the defenders, attackers and series of discontinuities that link the woollen overcoat or jacket to modern protective, breathable outerwear.

5. Describe an Aha! experience that you have had and try to think of the circumstances and background knowledge that may have triggered it.

6. Following your visit to the Ford centre, give an account of the size and time scale of the J curve associated with the introduction of a new model.

7. What examples did you discover at the Ford centre of innovation in design being triggered form events 'outside the square'.

8. Build up some S curves for the wool industry. You will need to do some research, but as a starter, look up and plot sheep numbers in Australia against time.

   What conclusions do you draw about the position of wool on its S curve?

   To get you started you have been issued with a copy of an Australian Bureau of Statistics article on the Australian wool industry. It can be found at: http://www.abs.gov.au/Ausstats/abs@.nsf/0/1476d522ebe22464ca256cae0015bad4?OpenDocument.