Ingenuity in Practice:

A guide for clear thinking

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Most of the time when we make decisions we take short cuts: it saves time and effort. We react instinctively on the basis of past experience (doing what we've done before) or we imitate others (doing what they've done before). This approach works very well until a crisis or a piece of luck forces us to change our way of thinking. The scale of the challenges facing humanity is unprecedented and we can no longer afford to muddle through. It is essential that we try harder to realise the full potential of our ingenuity. This text explains exactly how, with a little time and effort, this can be achieved. The return on that investment will certainly be considerable and could be enormous.

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Introduction

April 13th 1970

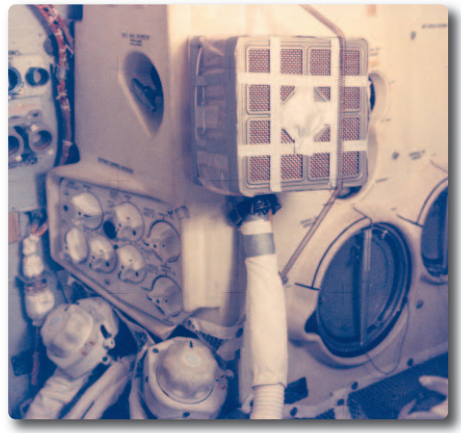
Swigert: *"Okay, Houston, we've had a problem here."*
Lousma: *"This is Houston. Say again please."*
Lovell: *"Houston, we've had a problem…"*

This exchange marked the beginning of one of the most remarkable rescues of all time. An oxygen tank aboard Apollo 13 had exploded. The space craft lost vital supplies of water, power and oxygen when the side of the service module blew away. An hour after the explosion it was realised that the three crewmen would have to move into the lunar module, which had its own independent supplies; they made it with about 15 minutes of power to spare. Using the module as a lifeboat had been discussed years before, but it was never considered a serious proposition. Unfortunately the lunar module was designed for two, with supplies for just 45 hours, and without the heat shields necessary for earth landing. And so there they were, 200,000 miles from home, still on course for a moon landing, and without the power to turn around.

As Lovell later remarked in his usual understated style, *"To get Apollo 13 home would require a lot of innovation."* From our point of view the most important quote is Flight Director Gene Kranz's initial reaction: *"Okay, let's everybody keep cool. Let's solve the problem, but let's not make it any worse by guessing"*

Over the next days an enormously complicated and interrelated series of problems were solved. Procedures which normally were written and tested over three months had to be ready in three days. As was said afterwards, failure was not an option: they had to get it right first time. Some operations were carried out with only minutes to spare. Some even involved the creative use of cardboard and duct tape.

Below: a very low-tech solution for the most sophisticated craft of the age. An improvised carbon dioxide filter – designed and prototyped on earth (left) replicated and successfully deployed in space (right)



On April 17th three very tired, hungry, cold, dehydrated astronauts returned to earth. In total Haise, Lovell, and Swigert weighed 31.5 pounds less; Lovell alone had lost 14 pounds. Just occasionally creative problem solving is a truly heroic pursuit.

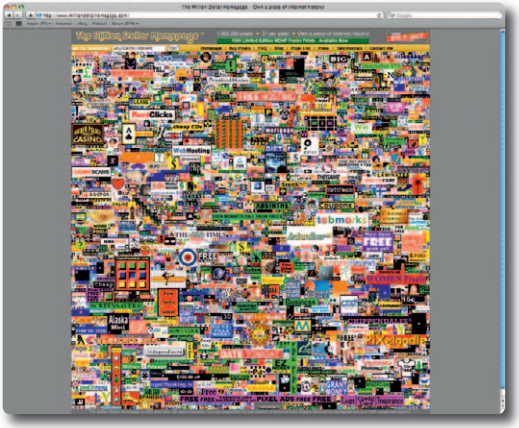
But innovation is not just about solving problems and making effective decisions: it's also about finding opportunities.

In August 2005 twenty-one year old student Alex Tew was trying to think of ideas to fund his further education without going into debt: *"after an hour or two of jotting down random things on paper, the idea seemingly popped out of nowhere. Almost like my subconscious mind had been ticking over in the background, working it all*

out. So it just kind of happened. That's about it. I scribbled it down and within about ten minutes a picture of what needed to be done had emerged."

That idea was the Million Dollar Homepage, an Internet phenomenon which sold advertising at the rate of one dollar per pixel. Less than five months later the final 1,000 pixels were sold in an online auction, and after costs, taxes and charitable donations Tew expected to net up to $700,000 profit from a start up cost of €50.

- This is a book for people who are still astonished at the skills, resourcefulness and sheer determination of the Apollo 13 team.



The Million Dollar Homepage

- This is a book for people who are amazed at the utter simplicity of the Million Dollar Homepage and say to themselves *'I wish I'd thought of that'*.
- It is also a book for people who are fed up with being told to be more creative, to *'think outside the box'* or *'you don't have to work harder, just work smarter'* and just want to know HOW.

The standard response to problems is often '**Don't bring me problems, bring me solutions!** Decisions have to be made with speed and certainty; Action not words.

If you have a problem just think about it really hard and **EUREKA!** the solution will appear. And if at first you don't succeed then try, try, and try again. If you don't succeed it's because you didn't want it enough. As for creativity, apart from the occasional 'genius', it's all a bit overrated and impractical really, isn't it?'

But as we shall see, the quick decision is not necessarily the best decision, ideas do not come out of thin air and 'creatives' are not special people.

Most of us have more than three days to work with and most of us are playing for lower stakes than the lives of three astronauts. Most of us have the luxury of seeing problems as opportunities, and many of us enjoy the further luxury of choosing which problems/opportunities we care to address. We are not suggesting that reading this book will enable you to salvage a moon mission: there is no short cut to competence. But we are suggesting that invention, innovation, effective decision making and entrepreneurship share the same basic problem solving process. This we can analyse and deconstruct in order to understand better how ingenuity works so that we can all enhance our thinking skills.

Take this problem as an example:

Despite or perhaps because of the information technology revolution the developed world seems to be disappearing under a mound of paperwork. More time seems to be spent target-setting, form-filling, and box-ticking than actually doing the job in hand. There must be a better way.

Our approach would be first of all to try and understand why we seem to need so much paperwork; is it accountability or transparency: is it a substitute for trust or commonsense?

Next, having identified the purpose of so much paperwork, we would ask whether there is not a more imaginative way to achieve that same purpose. What actually happens if we *'think the unthinkable'*: what if offices were to disconnect their printers; what if they banned e-mails and insisted on face-to-face meetings. What if you were limited to one phone call? Might that sort of *'off the wall'* thinking actually allow you to re-order your priorities and re-focus on the purpose rather than the process?

And if it turns out that there really is no alternative, then surely there must be a more practical way of doing it.

Finally, and most importantly, we would spend time examining the potential impact of new schemes before they are implemented rather than apportioning the blame afterwards.

Investment in ideas doesn't cost anything other than a bit of brainpower and as we will demonstrate generating ideas is what humanity does best.

Much of the literature of innovation starts from 'that Eureka moment' when an idea, solution or concept appears; we on the other hand will be starting earlier: **pre-concept;** that 'Houston, we have a problem moment'. We are going to try to solve problems and not make things worse by guessing.

In this book you will find a straightforward procedure for clear thinking which we consider has universal relevance, from business innovation to choosing your next holiday, from coping with global warming to organising your office.

We will demonstrate a technique for making decisions, solving problems and for recognising and evaluating opportunities which allows us to take time to examine the situation, come up with alternatives and choose the right one.

We will reveal where ideas come from, and demonstrate how to come up with new ones, helping to define creativity by placing it at the heart of innovation.

Moreover we will insist that creativity is a practical skill which can be taught and learned by everyone and that opportunities for innovation are to be expected; that's the nature of creative problem solving.

This is a book for optimists; people who still have that sense of wonder and possibility, or if they've lost it want to find it again.

This is a book about ideas and it is specifically designed to make you think.

Planet Earth seen from Apollo 13

Ingenuity in Practice

Why we need innovation - the scale of the challenge

Over the years there have been many philosophers and thinkers who have predicted the imminent downfall of the human race. Favourite reasons have been over-population, the depletion of vital resources, and the collapse of the established order.

One of the earliest of these pessimists is the Chinese philosopher and statesman Han Fei-tzu (280-233 BC):

'Nowadays, however, people do not regard five children as many. Each child may in his or her turn beget five offspring, so that before the death of the grandfather there may be twenty-five grand-children. As a result, people have become numerous and supplies scanty; toil has become hard and provisions meagre. Therefore people quarrel so much that, though rewards are doubled and punishments repeated, disorder is inevitable.' (Trans. Wenkui Liao)

And yet it will not have escaped the readers' notice that civilisation is still here; for that matter so is China, and that cannot just be a matter of good luck. Humanity has survived against all expectation through intelligence, creativity, invention and innovation – in one word - ingenuity.

The first of the modern doom mongers to take a scientific approach was Thomas Malthus:

"…I say, that the power of population is indefinitely greater than the power in the earth to produce subsistence for man."

This argument is as controversial today as when it was first published in 1798, in 'An Essay on the Principle of Population'.

For one early critic, the argument was palpable nonsense: *"The productive power at mankind's disposal is immeasurable. The productivity of the soil can be increased ad infinitum by the application of capital, labour and science."* (Frederick Engels 1843)

But over the last century population has been rising extremely quickly, probably a good deal faster than either Malthus or Fei-Tzu predicted and doubts are still being raised as to whether there is a limit to the technical solutions possible. Social solutions have their own difficulties: Garrett Harding's 1968 essay 'The Tragedy of the Commons' describes the way in which individuals, acting independently and rationally will bring about the depletion of finite resources in the full and certain knowledge that such a depletion is of long term interest to no-one. The forecast destruction of commonly held resources has the inevitability of Greek Tragedy.

In the same year ecologist Paul Ehrlich wrote 'The Population Bomb' which opened thus: *"The battle to feed all of humanity is over. In the 1970s the world will undergo famines – hundreds of millions of people are going to starve to death in spite of any crash programs embarked upon now."*

In 1980 Ehrlich accepted a wager from economist Julian Simon that raw material prices would fall rather than rise. The commodities, chosen by Ehrlich and his colleagues, were copper, chromium, nickel, tin and tungsten – the period of the bet was ten years. Ehrlich lost; every one of the metals fell in price.

Simon's explanation was that *"More people, and increased income, cause resources to become more scarce in the short run. Heightened scarcity causes prices to rise. The higher prices present opportunity, and prompt inventors and entrepreneurs to search for solutions. Many fail in the search, at cost to themselves. But in a free society, solutions are eventually found. And in the long run the new developments leave us better off than if the problems had not arisen. That is, prices eventually become lower than before the increased scarcity occurred."* ('The State of Humanity' 1996)

Since then the issue of climate change has intensified the debate. In 2006 the Stern Review on the Economics of Climate Change argued that strong, early action is essential to obviate the consequences of climate change. British Prime Minister Tony Blair stated the case plainly:

"This disaster is not set to happen in some science fiction future many years ahead, but in our lifetime." "Investment now will pay us back many times in the future, not just environmentally but economically as well." (BBC News 31 October 2006)

The extremes of the argument can be represented thus:

The pessimistic view is that of scientist James Lovelock who wrote that: *"…billions of us will die and the few breeding pairs of people that survive will be in the Arctic where the climate remains tolerable"* (The Independent 16 January 2006)

The optimistic view is that of 'cornucopians' who follow Julian Simon's *"…mind-boggling vision of resources: the more we use, the better off we become - and there's no practical limit to improving our lot forever. Indeed, throughout history, new tools and new knowledge have made resources easier and easier to obtain. Our growing ability to create new resources has more than made up for temporary setbacks due to local resource exhaustion, pollution, population growth, and so on."*('The Ultimate Resource 2' 1998)

A more temperate consideration of the situation appears in a report issued by The [British] Government Office for Science:

"The global food system will experience an unprecedented confluence of pressures over the next 40 years. On the demand side, global population size will increase from nearly seven billion today to eight billion by 2030, and probably to over nine billion by 2050; many people are likely to be wealthier, creating demand for a more varied, high-quality diet requiring additional resources to produce. On the production side, competition for land, water and energy will intensify, while the effects of climate change will become increasingly apparent. The need to reduce greenhouse gas emissions and adapt to a changing climate will become imperative. Over this period globalisation will continue, exposing the food system to novel economic and political pressures." ('Foresight. The Future of Food and Farming (2011)')

So on the one hand it is indisputable that we are still here, and for many people things have never been better in terms of health, life expectancy, material possessions etc. But just because Fei-tzu and others have been proved wrong time and again does not mean we can ignore the gloom merchants – predictions based on past performance are far from guaranteed. Moreover present day doom mongers have added considerably to the apocalyptic bill of fare – on top of the standard war, famine, pestilence and death we have climate change, worldwide pandemics, loss of bio-diversity: not forgetting asteroids and solar flares.

Whatever turns out to be correct, whether it is fate or arrogance or ignorance, one thing all parties do agree on: innovation has been and will continue to be essential to human progress and/or survival. Innovation in business; innovation in finance; innovation in technology; innovation in science; innovation in politics; innovation in organisations: indeed innovation in all walks of life – carrying on in the same old way is simply not an option (and, as we shall see, probably never has been).

But if the challenges are greater than ever, so is the potential for dealing with them. If in the past, we have relied upon human minds to solve problems, then we ought to remember that the number of minds has kept *exact* pace with the population and our access to them has increased beyond anything that has ever happened before. You could say that the World Wide Web represents the collective mind of humanity and the Internet our collective brain – we are all entering a new era whose possibilities we can scarcely grasp.

The concept of 'Peak Oil' is well known; the concept of 'Peak Water' is gaining currency, but it would be a very dismal person indeed who would predict 'Peak Ingenuity'. The human mind is readily available, inexhaustible and free at the point of use. It is our ingenuity that has kept us ahead of catastrophe and it is the optimism engendered by ingenuity that continually leads some of us to expect things to get better, not worse. We progress by solving problems.

Problems, Needs and Opportunities

The authors make no apology for using the word problem to describe the needs and opportunities which arise and the decisions which need to be made when crises occur. After all the word *problem* itself simply means something which has been *thrown forward*.

French philosopher and pioneer sociologist Gabriel Tarde wrote that every invention, like every discovery, is a response to a problem. *("…toute invention, comme toute découverte, est une réponse à un problème")* 'Les Lois de l'Imitation' 1890

To which we might add every *decision* is also a response to a problem.

Effective responses depend upon the quality and quantity of ideas from which to construct them.

The Nature of Change

When ideas are applied, that is, put into action, they bring about change. And so before we look at ideas we first need to look at our perception of the nature of change.

We tend to see change over time in one of two ways: either as a circle, turning and returning to the same spot; or as a line with a beginning and an end.

How are we to reconcile the cyclical nature of the world, *'time's cycle'*, with notions of continuous progress, *'time's arrow'?* Is progress gradual or step by step: is it continuous or discrete?

The work of economist and political scientist Joseph Schumpeter (1883 – 1950) brings the two together: time's arrow of economic progress meets time's cycle of the market. The market with perfect circular flow is going nowhere. What propels it forward is innovation.

"Capitalism, then, is by nature a form or method of economic change and not only never is but never can be stationary. And this evolutionary character of the capitalist process is not merely due to the fact that economic life goes on in a social and natural environment which changes and by its change alters the data of economic action; this fact is important and these changes (wars, revolutions and so on) often condition industrial change, but they are not its prime movers. Nor is this evolutionary character due to a quasi-automatic increase in population and capital or to the vagaries of monetary systems, of which exactly the same thing holds true. The fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumers, goods, the new methods of production or transportation, the new markets, the new forms of industrial organization that capitalist enterprise creates." 'Capitalism, Socialism and Democracy' (1942)

Schumpeter identifies two different responses to changes in the business environment: an *'adaptive response'* which is an adjustment of existing practice and a *'creative response'* which comes from outside existing practice. The adaptive is incremental change; the creative is revolutionary. The creative response destroys.

Old ideas, technologies, products, skills and equipment become obsolete. For Schumpeter the *'creative response is an essential element in the historical process: no deterministic credo avails against this'*.

It is the 'entrepreneur' who disturbs the equilibrium and is the driving force of economic development. The entrepreneur identifies and creates opportunities, takes action to realise those new ideas and keeps the *'engine in motion'*.

This breaking of the circle is happening continuously in different domains, along several time scales, interacting with economic cycles and fluctuations to cause a veritable ***'gale of creative destruction'***.

The distinction between creative and adaptive responses is resonant with the views of William Beveridge (1908 – 2006) in his 'Art of Scientific Investigation' (1957).

"Scientific research may also be divided into the exploratory type which opens up new territory, and the developmental type which follows on the former. The exploratory type is free and adventurous; occasionally it gives us great and perhaps unexpected discoveries; or it may give us no results at all. The developmental type of research is more often carried on by the very methodical type of scientist who is content to consolidate the advances, to search over the newly won country for more modest discoveries, and to exploit fully the newly gained territory by putting it to use. This latter type of research is sometimes spoken of as 'pot-boiling' or 'safety first' research."

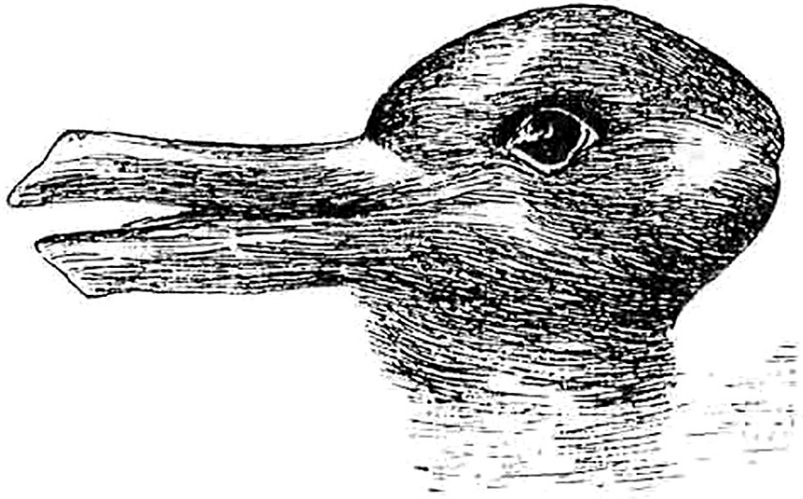
In 1962, Thomas Kuhn (1922 – 1996) published 'The Structure of Scientific Revolutions', arguing that science does not progress by a simple linear accumulation of knowledge, but is characterised by periodic revolutions. 'Normal Science' represents a linear progression of successful problem solving, until the pressure of unsolved puzzles or anomalies builds up causing a 'crisis' which is resolved after a period of 'Revolutionary Science' which overturns some or all of the previously accepted principles. The discovery of new facts and the invention of new theories mark these changes. For example, the earth-centred model of the universe was replaced by the sun-centred model. The new worldview accommodates the problems of the old worldview better and more fully, whilst setting a completely new array of puzzles to be solved.

But it is difficult for two views to co-exist as they lack a common measure. They look at the same thing in fundamentally different ways.

The new worldview may not necessarily explain everything that the old one did; there may actually be a loss of explanation. Hindsight often exhibits a bias towards narrative which tends to iron out the revolutionary nature of change, rendering it invisible.

(This is fascinating since it subverts that version of history which suggests a steady cumulative progress towards an ideal 'truth').

Kuhn would be little known outside of the philosophy and history of science but for his first use of two key terms which have entered popular culture. He describes the web of interwoven assumptions and beliefs which underlie normal science as a *paradigm* and the revolution which overturns it as a *paradigm shift*.



Kuhn used this famous image to illustrate the difficulties of shifting perceptions – is it a duck, or a rabbit – can it be both: is it neither?

In 2004 this statue (a gift from the government of India) was unveiled at the European Organisation for Nuclear Research. It embodies their work: Shiva Nataraja, the Lord of Dance, holds both the drum of creation and the fire of destruction at the same time: creation and destruction are inextricably linked, two sides of the same coin. In Europe however creation and destruction have had different relationships according to which is placed first. The phoenix has to die before it can be hatched in the ashes of its own destruction, whereas Oedipus is fully grown before he acts out his destiny and destroys his own father. When the nineteenth century anarchist Mikhail Bakunin recognised that the destructive passion was also a passion for creation he was surely thinking of the phoenix, but only a few years later it is Oedipus who casts his long shadow across western thought. European interpretations of Hinduism and classical Greek tragedy; the birth of archaeology; the rise and fall of ancient empires; psychoanalysis and economics, nihilists and Nazis: it's a heady brew with far reaching influence. Nietzsche was obsessed by the dynamic between creation and destruction and even today there's more than a slight odour of the Übermensch in some modern depictions of the entrepreneur as warrior hero.

*An **extremely** simple example of differing perceptions of the same data: A car park full of cars.*

We can classify them according to colour; so many red ones, so many blue etc. We can classify them according to size; large, medium or small. We can classify them according to country of origin; British, German, Japanese etc. We can classify them according to manufacturer; Ford, BMW, Toyota etc. Which method is 'best'? You cannot compare the different systems because they each use completely dissimilar measures; colour does not measure size. It all depends on your point of view. If we simply replace one system with another we lose some of the explanations of the old one. A full understanding of the array may well have to take into account all of these points of view.

In 1972 the palaeontologists Niles Eldredge (b. 1943) and Stephen Jay Gould (1941 – 2002) attempted to resolve the gradual/step-by-step dilemma in evolutionary biology with their Theory of Punctuated Equilibrium (1972). The concept of gradual, almost imperceptible change, interrupted by sudden episodes of revolutionary change echoed the nineteenth century accommodation between 'uniformitarians', who saw the present as the key to the past, and 'catastrophists', who saw the past as a very different place, filled with volcanoes, floods, earthquakes and ice ages.

So is change continuous or discrete? The answer surely is both: both creative and adaptive; exploratory and developmental; normal and revolutionary; uniform and catastrophic. The often complex relationship between these different kinds of change form the view which underpins this book; that periods of incremental advance, stability, certainty, even stagnation are interrupted by tempests which permanently alter the status quo, ushering in a brave new world. The challenge of trying to make sense of shifting paradigms and gales of creative destruction is illustrated by looking at just one domain with which we are all familiar.

The music industry has a long history - it's safe to say that people all over the world have been singing for their supper since time immemorial - but we shall take as a starting point the late nineteenth century in Western Europe and North America where there was a thriving industry selling sheet music to the general public.

A 'Paradigm Shift' from the world of medicine: Helicobacter pylori

In 1980 the treatment of gastric ulcers and gastritis was the subject of a vast body of medical literature; the major causes were thought to be stress and spicy food. Today most of these books are redundant and the recommended treatment for more than 90% of duodenal ulcers and up to 80% of gastric ulcers is a simple course of antibiotics.

Two Australian doctors, Robin Warren and Barry Marshall had suspected a link between ulcers and the bacterium helicobacter pylori. (Such a link had been suggested over eighty years earlier but was published in Polish and did not circulate widely) Their initial researches were met with scepticism by established medical opinion which only started to come around after Marshall proved the link by actually infecting himself and then effecting a cure through antibiotics.

In 2005 Warren and Marshall were awarded the Nobel Prize for Medicine for their work.

(N.B. the new 'paradigm' is not effective for 10 – 20% of ulcers which remain more explicable by the old.)

This do-it-yourself home consumption of music was itself quite a novelty, but the invention of the phonograph was something else. The original machine however was not even designed for music reproduction. In 1878 Edison listed ten possible applications of his invention, only two of which were music related. But playing music was the application that drove the technology. By the 1890s the average price of a wax cylinder was 50 cents, well within the reach of a mass market, but in what we will recognise as a familiar feature of the industry, a rival system appeared.

In 1887 Emile Berliner had patented the gramophone, which played discs. Flat discs were easier and cheaper to manufacture – even permitting a 'B' side to be pressed at the same time - although purists insisted that cylinders produced a

superior sound. The two systems carried on side by side until Edison finally withdrew cylinders in 1929. Disc continued as the most popular format for recorded music through incremental improvements in manufacture and technology; from clockwork to electricity as the power source; from brittle shellac to flexible vinyl.

But another technology had been developing alongside the disc which owed nothing to the wax cylinder. Magnetic recording was first demonstrated with metal wire as long ago as 1898 and can be traced through a different series of incremental changes; from wire to steel tape then coated tape; from ferric to chrome; from reel to reel to compact cassettes and eight track cartridges. These last two fight for a while before the cassette wins a brief victory until another revolution comes along. Just as there is no connection between groove and tape, there is no continuity with compact disc manufacture and anything which had come before; likewise the MP3.

Each development in popular music recording has been subject to the critical judgement of the market place. Some have succeeded and others have failed. Eight track cartridges and minidisk fell by the wayside but not necessarily because of any inherent faults in invention. The industry does not seem to tolerate radically different systems for long: uniformity is the norm.

And so we can trace threads of innovation both incremental and revolutionary: successive waves of creation and destruction. We can even note another of Schumpeter's predictions, the corporatisation of innovation, where the larger companies will produce several products in direct competition with themselves so that they won't be caught out.

Soap powder manufacturers have been delivering the same basic product in different formats under different brand names for years. For instance *Persil, Daz, Ariel, Surf, Bold, Fairy, Dreft, Lux* and *Tide* are available as powders, liquids, tablets and flakes and yet all of them are manufactured by either *Unilever* or *Proctor and Gamble*.

A common feature of innovation is that it is often resisted by vested interests. Recorded music was seen to be a threat to live music back in the 1920s. *'Home taping is killing music'* was the industry mantra in the 70s and 80s.

Another upheaval has taken place; a 'disruptive innovation' from outside the industry. The digital revolution did not confine itself to the music industry; personal computer ownership has soared, a myriad of bedroom producers are selling or giving away their music on the Internet. The music industry is now desperately playing 'catch up' having lost control of both the means of production and the means of distribution. Home taping, and all forms of non-industry copying, did not kill music; it encouraged it. The future of music was never in doubt; the future of the music industry is not so certain: the pie is greater than ever but the slices are much thinner. Ironically the best money spinner for musicians has been a return to playing live.

There is an important qualification to make before we leave the music industry. Tracing innovation back through a narrative of connections (and disconnections) and rivalries is a very simplistic method of study. Innovation does not happen in isolation; the breaking of the circle, as we said before, happens continuously in different, interacting domains. Those *'gales of creative destruction'* exist in a context. Back in the 1880s there was a background of mechanical reproduction of music other than by the direct recording of performance – music boxes, steam organs and player pianos. In the 1920s the problems of synchronising sound with moving pictures influenced innovation both ways. The rival technologies interacted; the last cylinders were actually reproductions of disc recording. Vinyl microgroove discs were reproductions of tape recordings. Tape allowed editing of the recording and so we see a shift away from live performance. In the 1970s transistor radios, increasing car ownership and a growing concept of portable music all had a part to play in the development of cassettes and cartridges, which in turn brought about another revolution, the personal stereo. Today the success or failure of DAB radio is likely to be dependant upon whether the automotive industry fits them in new cars.

We have already noted the digital revolution which brought the MP3 player but consider this: the present context includes millions of mobile phones with access to

the Internet which is capable of the simultaneous streaming of every music track ever recorded. Not only is the mighty iPod threatened, but the very concept of ownership is brought into question.

When the rental is so cheap, what is the point of ownership, whether physical or virtual?

From within the storm it can be very difficult to see what's going on and even more difficult to predict the outcome. It tends to be after the dust has settled that we are able to ask questions about how innovation works, where ideas come from and what exactly we mean by the word creativity.

We have seen change that is incremental or revolutionary or sometimes a mixture of both but is it a matter of pure chance or is it inevitable? Is innovation a simple logical process; each invention the foreseeable product of its context? What about the agents of change, the innovators themselves? Are they special people – geniuses – or are they just lucky?

Thomas Kuhn writes of the *'essential tension'* between innovation and orthodoxy, whilst Michael Shermer (2001) writes of *'the exquisite balance'* between heresy and orthodoxy in science. *'Heretic personalities'* know the rules well enough but are driven by their creative imagination to challenge assumptions and bring about paradigm shifts. This creative response is what Schumpeter identifies as the *'entrepreneurial spirit'*.

So where do these great leaps forward come from, these *'Eureka moments'*?

It is sometimes thought that ideas come out of thin air; that genius is *'inspired'* from the outside. Poets and painters seek their *'muse'*. Words like *'insight'* and *'illumination'* are used, providing neither insight nor illumination nor any real explanation of ***how*** the process works.

Beveridge writes that *'it is not possible deliberately to create ideas or to control their creation'* but the authors contend that there is a practical and straightforward way of encouraging human ingenuity which will allow us to do just that.

If we put to one side the notion that these moments of discovery are the result of some kind of outside intervention, and if we accept for the moment that these discoverers are not *fundamentally* different to the mass of humanity, and instead examine how *all of us* think, we may understand a little better how we solve problems, how we make decisions, and why we make so many mistakes.

If we could explain exactly where ideas come from we might start to understand exactly what we mean by the word creativity.

Retronyms

New products and processes bring new names to get used to – one of the attractions for first adopters of anything new is the jargon that goes with it, and the exclusivity that accompanies the jargon. You can always tell that radical innovation has been in action when we have to invent new names to describe old products – retronyms.

The first motion pictures were 'movies', then 'talkies' came along – by the time most movies became 'talkies' the term 'silent movie' had had to be invented.

What we call a 'penny farthing' was just a bicycle before the introduction of the 'safety bicycle', after which it was retronymed an 'ordinary'.

Before retail parks came along 'high street shops' used to be just 'shops'.

'Reel-to-reel' used to be just 'tapes' before the invention of cassettes.

The ubiquity of mobile phones means that an ordinary telephone is now a 'land line'.

Pocket watches were just watches before the wristwatch.

'Analogue' watches used to be just 'watches'.

The first digital watches referred to the display rather than the mechanism.

Digital technology (which pedants insist should properly be called 'binary') is now the norm in photography and so 'ordinary' cameras are now also called 'analogue'

"What we call [creativity] is in reality a composition — a construction raised on … material of the mind, which must be collected … by the senses. … We are unable to 'imagine' things that don't actually present themselves to our senses."

Educationalist Maria Montessori (1870 - 1952)

How we solve problems

Ordinarily we re-use previous experiences to solve problems; we do what was successful last time. We learn what works by trial and error.

The psychologist Max Wertheimer (1880 – 1943), called this 're-productive thinking'. People often call this 'common sense'.

When trial and error does not work we look at the problem more closely; re-presenting it, restructuring it, using our imagination, seeking solutions.

Wertheimer called this 'productive thinking'. This is the creative part of problem solving; this is when we say 'aha!' People tend not to call this common sense, but instead use words like *insight*, *inspiration*, even *genius*, depending on how good an idea we think it is. The best of these solutions, the ones which we think of as most creative, are those which are radically different to what went before, those which seem to 'come from nowhere'.

All of us, (or very nearly all), use imagination in this way to create new concepts from old. **And so, to a greater or lesser degree all of us are creative.**

Most of the time we do this automatically, almost unconsciously. From our bank of experience we generate and evaluate ideas so quickly that the process seems almost instantaneous. If we don't like the idea we think again, gathering more facts,

Genius is a very troublesome word, which we will return to later. For now, however, let's note that we often use the word when we are taken aback by ideas of such quality that we cannot measure them in ordinary terms. We use the word at the very moment of our changing perception, precisely because of the incommensurability of paradigms. But we should also note that when someone says 'new' they nearly always mean 'new to me'; they haven't seen all the work that came before.

searching our memory, finding similarities and analogies, generating more ideas, and evaluating once more. We repeat this procedure until we reach a solution we do like.

This representation of human problem solving sounds quite mechanical and so we are going to pursue that thought by asking the question *'How do machines solve problems?*

How machines solve problems

A model of problem solving which has been very successful for machines is case-based reasoning, which was originally developed by Roger Schank and others at Yale University as part of their work on artificial intelligence.

When faced with a problem, the first reaction is to recall a similar case, and approach the problem accordingly. This is formalised into four stages:

1. RETRIEVE (from memory) the most similar case or cases
2. REUSE the information and knowledge in that case to solve the problem
3. REVISE the proposed solution (this corresponds to our creative stage)
4. RETAIN (commit to memory) the parts of this experience likely to be useful for future problem solving, i.e. learn

The machine can do this effectively by the sheer power of its computation. However it is limited by the quality of its knowledge base. Where the knowledge base is finite, computers ought to outperform humans every time; their capacity for error is smaller, their logic inexorable.

(Which is why they're so good at chess, but the ability to play chess at grandmaster level is one which most of us throughout history have managed quite well without).

For more abstract problem solving, computers are still some way behind humans, despite the fact that humans are far less logical than machines. For example cognitive dissonance, the ability to hold two or more opposing views at the same time, is commonplace for humans; very difficult for a computer.

For practical purposes we are not going to take the brain-as-computer metaphor too literally (although some researchers do). The human brain after all has a somewhat different history; both as individuals and as a species, we have been shaped by experience.

No one teaches us how to think, we do it unconsciously. Just as our hearts pump and our lungs breathe, our brains think and learn and the knowledge that we acquire through life is much more than a list of facts; we learn skills and develop capabilities as well as accumulating information.

> *"The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it."*
>
> From the conference proposal for the Dartmouth College Summer Research Project on Artificial Intelligence in New Hampshire, U.S.A. in 1956.

Knowledge and Knowing

The scientist and philosopher Michael Polanyi (1891 – 1976) formed the concept of *'tacit knowing'*. It is summed up by his aphorism *'we know more than we can tell'*.

Tacit knowing is often described as *know-how* as opposed to *know-about*.

Tacit knowledge and knowing must be learnt; it cannot simply be taught. An easy example is swimming: all the instruction books in the world will not *teach* us to swim; it is only by practical experience that we can *learn* to swim. And it is only with continuing practice that we improve our skill. *We have to get our feet wet*.

The picture is complicated by the fact that tacit knowledge and knowing can be recognised within organisations, and that these skills vary from group to group. For example every orchestra will interpret an identical score in a very different fashion, even when the same conductor wields the baton. Every week we see sports teams which somehow perform beyond expectations. The team which exceeds the sum of its parts can defeat the team which does not play together. How can we gauge the house style or ethos of a group of individuals? How do we pass on skills which we cannot measure or even define?

To return to the music industry, there is a general consensus that when Tamla Motown records moved from Detroit to Los Angeles something changed. The tacit knowing which made up the 'Motown sound' did not travel and aficionados can tell the difference.

The concepts of tacit knowledge and tacit knowing raise all sorts of difficulties: to what extent can tacit capabilities be transferred; can they be codified or articulated and so become explicit knowledge?

But in *practice* we must recognise the importance of tacit capabilities, and a judgement has to be made between the amount of tacit understanding to be imparted and the trust that explicit knowledge can be accurately interpreted. The pragmatic approach needed to achieve that sort of balance might be better appreciated by reference to what some artificial intelligence researchers have codified as *commonsense reasoning*:

- Reasoning with knowledge that we cannot prove.
- Reasoning rapidly across a wide range of domains.
- The ability to tolerate uncertainty in our knowledge.
- Coming to conclusions without complete knowledge and the ability to revise those decisions or beliefs as better knowledge becomes available.

The study of how the brain works is really still in its infancy. The first undergraduate course in neuroscience was only offered as recently as 1973. (Amherst College, U.S.A.) The structure and processes of the brain, its relationship to the mind and the nature of consciousness itself are at the absolute cutting edge of human understanding. Advances in neuroscience are going to change the way we think about ourselves, but we don't need to know all about frontal lobes, cortices or synapses to be able to use our brains more effectively. *(After all you don't need to understand how a bicycle works in order to ride one.)* But we will need a working hypothesis.

J. P. Guilford (1897–1988) proposed a structure of intellect divided into general processes or operations:

- Cognition - the ability to recognise, discover, and comprehend information.
- Memory - the ability to record, retain and recall information.
- Divergent production - the ability to produce multiple solutions to a problem.
- Convergent production - the ability to deduce a single solution to a problem.
- Evaluation - the ability to assess the validity of a solution.

Guilford felt that creativity was to be found in divergent thinking and was characterised by fluency (the creation of a large number of ideas) flexibility (simultaneous production of a variety of approaches) originality and elaboration.

If we construct a very basic model of how we think linking re-productive and productive thinking with convergent and divergent elements we have a practical framework with which we can understand how we learn and why we make mistakes.

Human Commonsense Reasoning

An incident on the football field: the striker goes down, rolling and writhing into the penalty area; the defender backs out of the area protesting his innocence; the ball rolls free, the linesman's flags stay down and the referee waves play on. The crowd is in uproar, the commentators are in uproar as well; either it was a foul or it was not. Either the defender gave away a free-kick or he did not; and if he did it inside the area then it's a penalty. If it wasn't a foul then the striker is guilty of simulation and must receive at least a yellow card, if not a sending off. The referee has obviously 'bottled it' by failing to make a decision.

But let's look at it from the referee's point of view. It's a prime case of having to reason with incomplete information. He cannot prove who was at fault; his assistants did not see anything and this sport does not allow referral to a video umpire. He needs to make a decision quickly and so he looks at the bigger picture. Will the outcome of the match be affected either way by his decision? Quite possibly, especially if he awards a penalty or a sending off. But the incident occupied less than thirty seconds out of ninety minutes. And as the match progresses he can use the information gained to make a better assessment of the players involved, and referee accordingly. And so he does make a decision, which is to tolerate uncertainty, trusting that the refereeing panel will agree with him and give him the next match. Of course, what often happens is that with the players, coaches and crowd all baying for his blood, and with the whole incident being replayed in slow-motion on the big screen, the referee, in a vain attempt to restore his authority, totally overreacts to the next incident and once more calls his parentage into question. That's commonsense reasoning, and that's what machines find so hard to do. And that's why, despite all the emphasis on winning or losing, it is in fact *how* the game is played that keeps us humans watching. That and of course the pleasure of having someone to blame!

As with the computer the quality of the output is limited by the quality of the input; the more effective we are in each of these operations, the more effective will be our thinking.

The GIGO principle (Garbage In Garbage Out) has been around since the birth of the computer:

"On two occasions I have been asked, - 'Pray, Mr. Babbage, if you put into the machine wrong figures, will the right answers come out?' - I am not able rightly to comprehend the kind of confusion of ideas that could provoke such a question."

Inventor Charles Babbage (1791 – 1871) writing in 1864.

As we said earlier our minds are shaped by our experiences; and our ancestors minds were shaped by their experiences. If a sabre-toothed tiger is chasing you, thinking quickly is the name of the game. The system is built for speed and perhaps this is why ideas sometimes seem to come *'out of the blue'*, when we are no longer thinking actively; maybe the computation needs time to catch up.

The other consequence of this need for speed is that we apply the *principle of least effort;* we nearly always go for the first acceptable solution to a problem rather than have to wait for what we perceive to be only a marginally better one. We tend to find answers in the central part of the bell curve of normal distribution, not bothering to pursue significantly better solutions may require a little more effort to find around the edges.

And this rush to judgement is another opportunity for us to make mistakes. There is a tendency to equate good decision making with rapid decision making. The 'alpha male', (or female), will invoke Winston Churchill's habit of labelling documents *'Action This Day'*. They unfortunately ignore the fact that Churchill also used tags reading *'Report in Three Days'* and *'Report Progress in One Week'*. (Bearing in mind the pressures of time, we ought perhaps to remember the old Hollywood adage, *'you can have it good or you can have it on Tuesday'*)

If we dissect the thinking process we are able to see more clearly.

- We can adopt a more analytic approach.
- We can adopt a more imaginative approach.
- We will have the opportunity to search for creative possibilities.
- We will enhance our chance of finding the optimal rather than the acceptable.

It's a lot cheaper in time as well as money to make a little extra effort at this pre-concept stage, and take a little more trouble at the planning stage than to rush into a project and find yourself saying; *'of course, if we had the chance to do it again…'* Less haste should result in more speed and wasted time is wasted opportunity.

Entrepreneurial Thinking

The word 'entrepreneur' has come to be used very loosely and often indiscriminately to include almost anyone involved in new businesses, from self-employed sole traders to multi-million pound venture capitalists. It is worth returning to Joseph Schumpeter for a more precise explanation of the term he popularised:

"…everyone is an entrepreneur only when he actually 'carries out new combinations,' and loses that character as soon as he has built up his business, when he settles down to running it as other people run their businesses. This is the rule, of course, and hence it is just as rare for anyone always to remain an entrepreneur throughout the decades of his active life as it is for a businessman never to have a moment in which he is an entrepreneur, to however modest a degree." ('The Theory of Economic Development' 1934)

So we see that Schumpeter is using entrepreneurship to describe an activity rather than a person; the entrepreneurial spirit being a quality possessed, to a greater or lesser extent, for a longer or shorter time, by those people who are agents of change through their 'creative response' to situations.

Creative problem solving encourages entrepreneurial thinking by identifying imaginative possibilities which may turn problems into opportunities.

The authors do not measure entrepreneurship solely in monetary terms. Just as the costs of innovation are not necessarily financial, so the benefits of innovation cannot always be expressed as the bottom line in an account book. For example, where welfare is the prime consideration the term 'social entrepreneurship' is sometimes used to describe actions which increase 'social capital'. Lower crime figures, less pollution, increased life expectancy, quality of life, even world peace, liberty and the pursuit of happiness can be the goals of social entrepreneurship. (This is not to suggest that the goals of social entrepreneurship may not have to be paid for in financial terms, nor that the benefits may include financial reward.)

The authors describe the entrepreneurial spirit as that which identifies and creates opportunities and then takes actions to realise new ideas in an appropriate market in such a way as to bring value that is recognised in that domain.

But entrepreneurial thinking can also be used pro-actively: by would-be entrepreneurs trying to identify and anticipate problems/opportunities which they can solve in such a way that brings value, some or all of which may be turned into financial reward. For such 'problem seekers' it is important to note that certain areas of problem solving offer more, and different opportunities than others.

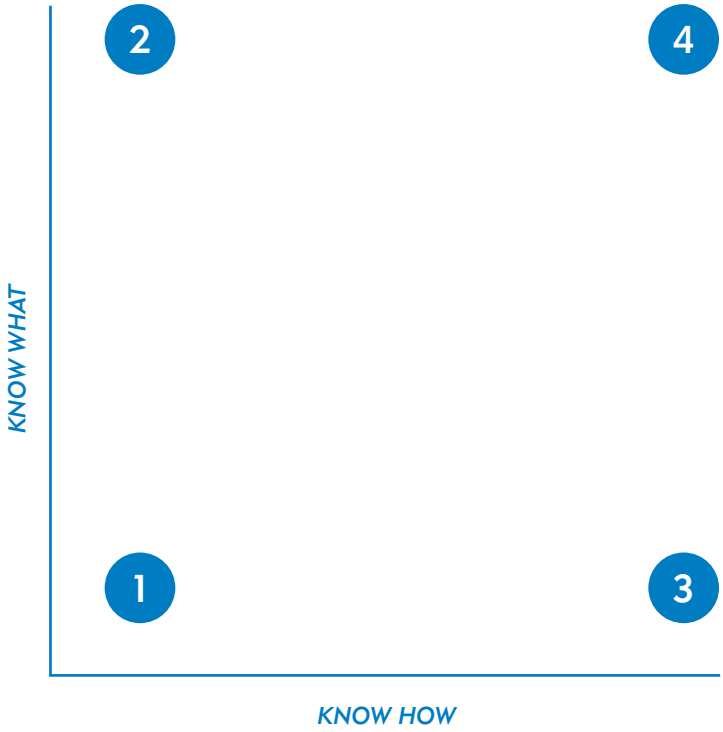
"The principal goal of education in the schools should be creating men and women who are capable of doing new things, not simply repeating what other generations have done; men and women who are creative, inventive and discoverers, who can be critical and verify, and not accept, everything they are offered."

Developmental Psychologist Jean Piaget (1896 - 1980)

Geoff Kirk, former Chief Designer at Rolls Royce and visiting professor at Nottingham University Business School, uses the graphic illustrated below to discuss types of problem.

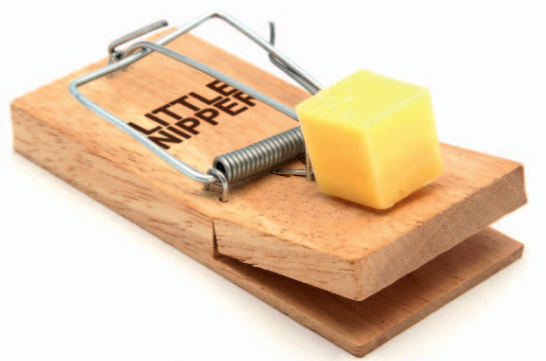
The vertical axis describes the extent of our knowledge about the problem/opportunity/need. The horizontal axis describes the extent of our ability to address the problem/opportunity/need.

The extreme corners could be exemplified thus:

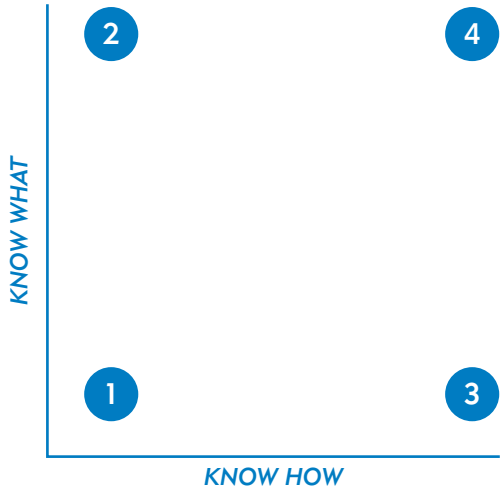


Kirk's Space

1. Bottom Left is our starting point – we are not quite sure what the problem is and we are not at all sure about how to solve it, for example global warming.
2. Top Left is where we have a clear and unequivocal idea of the problem to be solved – where we want to be. On May 21, 1961, President Kennedy proclaimed to the United States Congress that *"this nation should commit itself to achieving the goal, before the decade is out, of landing a man on the moon and returning him safely to the earth."* At the time NASA had only very sketchy ideas on how that might be done but on July 20, 1969, Apollo 11 fulfilled the aspiration with five months to spare.
3. Bottom Right is where we have a clear understanding of our capabilities and are looking for ways of using them. On Monday 10 September 1984, at 9:05 a.m. Alec Jeffreys, (now Sir Alec) had what he described as a 'Eureka Moment' when he took an X-ray photograph of his assistant's genetic code from the developing tray. Seeing the similarities and differences in the results of experiments on his technician's family made him realise that he could trace the links between their unique genetic profiles. In this case most of the potential applications of what would become known as genetic fingerprinting were apparent to Jeffreys and his team almost immediately although the detailed implications are still being worked out.
4. Top Right is where we all want to be – the perfect solution, for example in 1897 James Henry Atkinson invented the 'Little Nipper' mouse trap which is still being manufactured with an estimated 60% market share.



A better mouse trap



Kirk's Space

So what are the entrepreneurial opportunities in each of these corners?

4. Top right – the opportunities are restricted; the problem seems to have been solved already. There is an existing market but the budding entrepreneur is going to have to make a compelling case to customers why they should change – price, quality, efficacy, service etc. Plus the existing solution provider is likely to react to competition.
3. Bottom right – the opportunity is to identify objectives that can be attained with a particular capability.
2. Top left – the opportunity rests with identifying the capabilities needed to achieve the stated objective.
1. Bottom left – this is the area of most opportunity; the area where the entrepreneur *'carries out new combinations'* matching goals with capabilities in a hitherto unrealised fashion. The German philosopher Arthur Schopenhauer (1788 – 1860) is credited with this observation: *'Talent hits a target no one else can hit; Genius hits a target no one else can see.'* We shall come to a technique for finding problems later but first we need to understand a little more about them.

Types of Problem

Just as certain areas of problem solving are more fruitful than others certain types of problem are less open to entrepreneurial solutions.

In 1974 Hungarian architect, engineer, and sculptor Ernö Rubik invented the puzzle which bears his name. The 3x3x3 cube has 43,252,003,274,489,856,000 possible combinations on its six faces. The first international competition was held in Hungary in 1982 and was won in a time of 22.95 seconds. Nowadays under ten seconds is the benchmark for serious puzzlers. Whilst most of us are amazed by such abilities the problem itself is a straightforward one – despite the enormous number of combinations it is a finite number and there is only one solution.

'Real Life' is not like a Rubik's Cube – there are innumerable combinations and more than one way forward.

Take, for example, a more commonplace problem – what to have for breakfast. Apart from those unfortunates who literally have nothing to eat, this is a problem addressed by everybody throughout the world every single day. Solutions vary, from smoked salmon with quails' eggs to a can of coke and a packet of potato crisps. The staple food will vary – rice, wheat, oats, maize – as will the form it is processed into. There is clearly more than one 'solution' to the problem of what to have for breakfast, and those solutions depend upon cost, availability, and convenience.

And so what appears to be a simple problem (breakfast) is in fact enormously complicated, whereas the apparently complicated Rubik's Cube puzzle turns out to be simple.

The contrast is succinctly explained in the abstract of a paper entitled 'Dilemmas in a General Theory of Planning' (Rittel and Webber 1973):

"The search for scientific bases for confronting problems of social policy is bound to fail, because of the nature of these problems. They are "wicked" problems, whereas science has developed to deal with "tame" problems. Policy problems cannot be

definitively described. Moreover, in a pluralistic society there is nothing like the undisputable public good; there is no objective definition of equity; policies that respond to social problems cannot be meaningfully correct or false; and it makes no sense to talk about "optimal solutions" to social problems unless severe qualifications are imposed first. Even worse, there are no "solutions" in the sense of definitive and objective answers."

Note: the terms simple or complex, tame or wicked, bear no relation to the ease or difficulty of solving the problem. What to have for breakfast, a complex problem, is solved every day whereas decoding the human genome, a simple problem, is taking a little longer. What Beveridge somewhat disparagingly called 'pot boiling' science is of course a long and difficult enterprise. But as an opportunity for creative problem solving and entrepreneurial enterprise what to have for breakfast is a far more attractive area.

A simple problem – it might be difficult but it is tame, there's only one solution

A complex problem with innumerable solutions; wake up and smell – what?

Entrepreneurial experience: taking on the problems no one else can solve…

…and spotting the opportunities no-one else can see

In order to gain that precious 'know how' as well as the 'know about' of entrepreneurship education every student entering Nottingham University Business School is expected to place themselves in the bottom left hand corner of Kirk's Space and come up with brand new concepts in areas such as ageing populations, sustainable local energy supplies, lack of fresh water etc. But more importantly students are challenged to look for opportunities beyond those well known problem areas because the most radical innovations are in solving the problems no-one else can see:

For example so called latent or dormant needs – fifteen or twenty years ago no-one *needed* a mobile phone and yet nowadays mobiles are *essential* accessories for at least half the people in the world and are seen as a key element in economic development in the poorest countries.

Creative Problem Solving and Effective Decision Making

In the last hundred years or so an increasing number of formal problem solving methodologies have been developed across a wide range of domains, from industry to advertising.

- George Polya's 'How to Solve It' (1945) has been enormously influential far beyond its original domain of mathematics.
- TRIZ, the heuristic/algorithmic system developed by Genrich Altshuller in post-war Russia has a devoted following outside of engineering.
- In the area of creative idea generation Alex Osborn's *'brainstorming'* has entered the language as has Edward de Bono's *'lateral thinking'*.
- Lumsdaine and Binks (2003, 2005) highlight the importance of recognising and balancing different thinking styles, and also lay particular emphasis on entrepreneurship.

It is probably fair to say that some problem solving techniques have become more detailed and specific as time has gone on. Some of the most interesting deserve to be better known beyond their particular sphere. For example, fans of ad-man James Webb Young's 'A Technique for Producing Ideas' (1940) which emphasises incubation, ought to be just as interested in William Beveridge's insistence on the importance of chance in scientific progress.

Many design and management methodologies show signs of cross-pollination. Some techniques are public domain, others are quite strictly copyrighted. Some are more useful than others. Some are at best the *"professionalisation of common sense"* (Dr. Ben Goldacre 'Bad Science' 2009). Others are fairly dubious:

> *"It seems to me what is called for is an exquisite balance between two conflicting needs: the most skeptical scrutiny of all hypotheses that are served up to us and at the same time a great openness to new ideas … If you are only skeptical, then no new ideas make it through to you … On the other hand, if you are open to the point of gullibility and have not an ounce of skeptical sense in you, then you cannot distinguish the useful ideas from the worthless ones."*
>
> Scientist and writer Carl Sagan (1934 – 1996)

'About Learning' (2005), the Report of the Learning Working Group of the respected think tank Demos quotes Harvard Professor Howard Gardner's concerns about the representation of his [itself controversial] theory of Multiple Intelligences (MI).

"…I learned that an entire state in Australia had adopted an educational program based in part on MI theory. The more I learned about this program, the less comfortable I was. While parts of the program were reasonable and based on research, much of it was a mishmash of practices, with neither scientific foundation nor clinical warrant. Left-brain and right-brain contrasts, sensory-based learning styles, 'neuro-linguistic programming,' and MI approaches commingled with dazzling promiscuity."

Our purpose is not to replace or reject any of these techniques but to reference them whilst offering a broader guide for clear thinking which should enhance creativity, innovation and effective problem solving right across the board from business to politics, from arts to science.

The problem solving methodology expounded in this book was developed at the University of Nottingham as a tool for entrepreneurship education. It has been taught to thousands of students from all over the world at our campuses in the U.K., China, and Malaysia.

It has also been very well received by a wider audience of academics, professionals, business leaders and managers through our Executive Education Programme. It is an integral part of ongoing programmes for an ever increasing range of organisations from small and medium-sized businesses to listed multinational corporations; from high growth entrepreneurs to large public organisations like the National Health Service.

The Ingenuity Creative Problem Solving Process

We propose a relatively simple problem solving structure:

1. **Definition** – spending more time finding root causes, understanding how problems are constructed and interrelated.
2. **Discovery** – making the effort to look as widely and as imaginatively as we can for ideas that we can engineer into creative possibilities.
3. **Determination** – using sound judgement to foresee the likely consequences, turning possibilities into probabilities.

Each of these phases should be separated to allow ideas to incubate, to soak.

When we separate and 'slow down the thinking process' this does not necessarily mean postponing or delaying decision-making. When we 'put something on the back-burner' it's in the full expectation that when we return to it, it will have cooked.

Fractals are a fascinating and extremely fashionable branch of mathematics. The term was coined by Benoit Mandelbrot in 1975 as part of the mathematical description of recursive self-similarity. In popular usage self-similarity is when a pattern can be successively broken into smaller parts each of which exhibits the same qualities as the one before. A feedback loop from very simple rules iterates into complexity.

And so it is with this problem solving process – what may appear daunting is in fact a very simple repetition of three distinct phases made by the deliberate separation of convergent and divergent thinking styles, together with an insistence on allowing time for reflection.

Thus:

1. *We pose a question.*
2. *We look at the alternatives.*
3. *We choose from the alternatives.*

Each stage reflects the following characteristics:

1. *Definition is all about preparation. What do we know and where do we want to be? Questioning, Investigative, Diagnostic, Methodical, Analytic, Clarity of vision.(The vertical axis of Kirk's Space)*
2. *Discovery concerns idea generation. How can we engineer possibilities? Freethinking, Open-minded, Relaxed, Uncritical, Non-judgemental. Fuzzy and tolerant of uncertainty.(The horizontal axis of Kirk's Space)*
3. *Determination is idea evaluation. A return to a focussed vision. Judgement and choice. Critical, Logical, Reasoned. Assessing the possibilities, have we made progress? (Bringing together vertical and horizontal axes)*

The results of stage 3 (evaluation) should form the basis of stage 1 (preparation) of the next phase. If it does not then you must return to the start. It is an iterative process.

Fractals in nature – Romanesco broccoli. It might look complex but it's broccoli all the way through!

Interlude

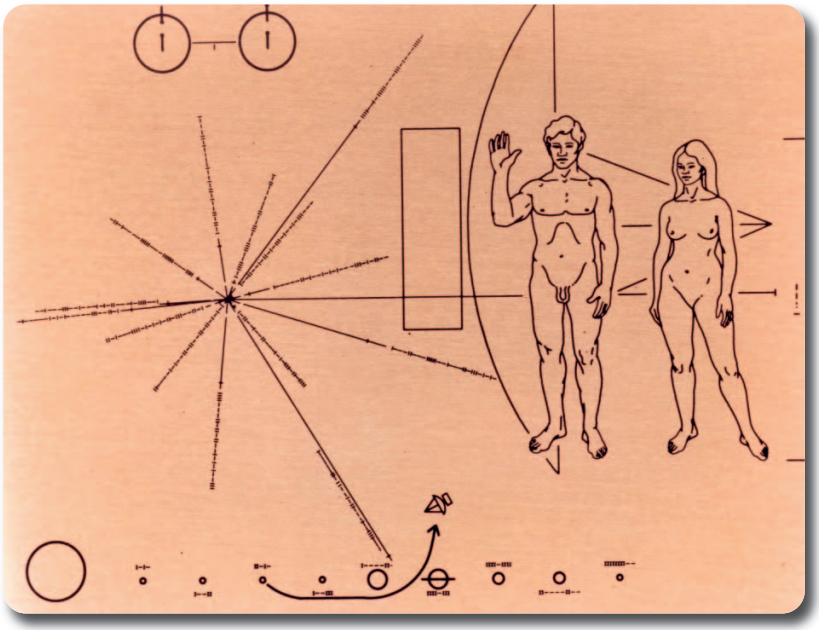
A paradox

Imagine that you are in a spaceship travelling towards some distant star. One day you look in the equivalent of your rear-view mirror and see a faster vessel overtaking you.

This vessel, oddly enough, is from your own planet; it set out years after your departure and is the result of enormous improvements in space technology since your day.

What was the point of you setting out at all? Why bother?

The second spaceship ought to pick you up and continue before it is overtaken in turn and everybody climbs aboard the latest technology; just as happens in practice with any radical innovation – sooner or later we all jump ship, whether it be from vinyl to digital or fountain pen to biro.



The first two spacecraft sent on course to leave the solar system, Pioneer 10 and 11, each bore a plaque with some basic information about their place of origin.

There is a parallel with the very down to earth problem of personal pension provision – when is the best time to start saving for your retirement?

At the start of your working life, when it seems a long way off and you are comparatively poor?

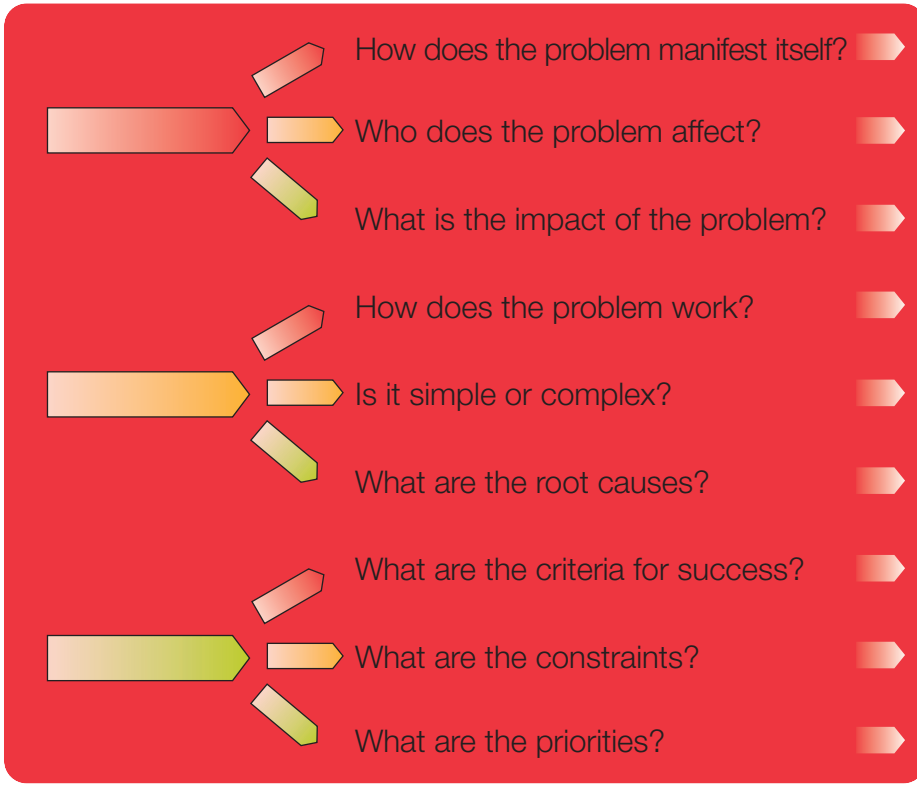
Towards the end, when you begin to panic, but are hopefully more able to afford it?

There ought to be a perfect moment, or moments; a sliding scale of increasing contributions based on projected earnings and life expectancy – the sort of complex calculation so beloved of financial advisers. And indeed such speculative calculations can be used to predict the best time to set off to another planet, but the resolution of this paradox is surely that the second spaceship would never have been invented but for your efforts: this is one of the things we mean when we say that we see further because *'we stand on the shoulders of giants.'*

But the paradox also suggests a more general question about waiting for someone else to solve our problems. Why not call in the experts? American writer Paul Lutus (b. 1945) addresses the consequences of this attitude; he divides us all into people who know how to think, *'idea producers'*, and those who do not think for themselves, *'idea consumers'*. He is especially hard on the latter:

"The content of their experience is provided by television, the Internet and other shallow data pools. These people believe collecting images and facts makes them educated and competent, and all their experiences reinforce this belief. The central organizing principle of this class is that ideas come from somewhere else, from magical persons, geniuses, them*".*

Lutus highlights the distinction between ideas and facts. So before we start having ideas, let's establish some facts.



The fractal nature of the problem solving process means that each phase will tend to reflect the overall structure. Thus within 'Problem Definition' there will be three smaller phases of definition, discovery and determination which should be characterised by alternating convergent and divergent thinking styles.

Phase One: Definition

"The greatest obstacle to discovery is not ignorance - it is the illusion of knowledge."

Daniel J. Boorstin.

This section is all about preparation. We need to establish the facts.

Where are we now and where do we want to be? The mood should be focussed and analytic; the thinking style associated with the left hemisphere of the brain. Linear, logical, sequential algorithmic processing.

- How can we 'drill down' to find root causes?

We need to look at the nature of information.

In 1948 Claude Elwood Shannon published 'A Mathematical Theory of Communication', coining the term *'bit'* (binary digit), essentially a yes/no answer.

For example, it takes on average 5.7 bits or yes/no questions to find a card picked from a pack of 52 (the power to which 2 must be raised in order to result in 52 alternatives).

The sequence is 2, 4, 8, 16, 32, and 64. Since 52 lies between 32 and 64, the number of bits must be between 5 and 6, in this case, on average, 5.7.

New Coke; a cautionary tale

"There is a twist to this story which will please every humanist and will probably keep Harvard professors puzzled for years,"

Donald Keough (President Coca Cola)

There will almost certainly never be a definitive account of the introduction of New Coke but the bare bones of the tale are as follows:

In the nineteen seventies Coke's great rival Pepsi started an advertising campaign, 'The Pepsi Challenge' in which Pepsi was consistently preferred over 'other leading brands'.

By the nineteen eighties Coke was running scared, seeing significant inroads into their market share, especially in supermarkets. Coke's response was to reformulate the taste of Coca-Cola, which they launched on April 23rd 1985.

Following a public outcry the company announced the re-introduction of the original formula on July 10th 1985. After the dust had settled Coca-Cola were left with a larger market share than before. What appears to have happened is that Coca-Cola never really identified the root cause of their loss of market share and jumped to a solution to a problem that was not there, in the course of which they ditched their most valued asset – brand loyalty.

Their real problem was the perennial 'How do we maintain and increase our market share?' and was eventually answered by doing the one thing they initially did not want to do, which was to increase their line. Nowadays the shelves are filled with variations: Cherry, Caffeine-free, Diet, with lemon, with lime and Coke Zero.

Donald Keough's response to speculation that it was all a publicity stunt was *"we're not that dumb and we're not that smart"*

Conclusion: *"There is always a well-known solution to every human problem — neat, plausible, and wrong."*

American writer H. L. Mencken (1880 – 1956)

20 bits of information, or 2 raised to the power 20, discloses 1,048,576 possibilities.

In this way twenty questions simply answered yes or no have the potential to find one answer in a million. The technique is the basis of several modern television panel shows and parlour games, but has certainly been around for about two hundred years and possibly much longer. Bits and bytes are binary numbers and we are not limited to base two. We can get further and faster by tailoring our questions to suit the circumstances.

Within any finite system it should be possible to devise and use diagnostic questions just as car mechanics do every day. Over the years a number of formal heuristics have been developed in a variety of domains from engineering to creative writing. Obviously not all the questions are relevant in different domains but it is remarkable the similarities that all problems have in common. Also remarkable is the way that some widely differing domains provide insights into each others problems. For example, asking a question about engineering from an emotional point of view might seem irrelevant, or even fatuous, but substitute the word 'stress' for 'emotion' and it may be more significant. Checking fuel and battery levels are the first thing a roadside repairman does, just as an accountant will check the balance sheet and cash flow.

It helps to adopt the attitude of an insistent child who keeps asking the same question over and over again; why? why? why? until they have extracted every last jot of information.

(Sakichi Toyoda formalised this as '5 Whys' and used it as part of Toyota's problem solving process, although the first thing to be said is that 5 is not the definitive number of times you should ask 'why?', you may need less, you may need more, and you need to know when to stop!)

Most problems do not have guaranteed solutions. As we saw with the concept of commonsense reasoning quite often we have to tolerate uncertainty. Just as we often end up telling insistent children that they might have to find out for themselves.

NOTES:

"Some people, the moment they have a device to construct or any piece of work to perform, rush at it without adequate preparation, and immediately become engrossed in details instead of the central idea. They get results but they sacrifice quality."

Nikola Tesla (1856 – 1943)

Define: analyse the evidence; describe the symptoms

To describe a problem, what better start than the classic six questions which every journalist is supposed to ask: who? what? when? where? how? and why?

Because our problem solving process is so wide ranging, not all the questions we suggest will be as relevant as others.

How does the problem manifest itself?

- In other words, how did it come to your attention? Was it a sudden failure or did you feel it coming? Letters in the post or a phone call, or is it one of those nagging problems that has always been there?
- What are the symptoms? Describe the problem.

  For example: *'I feel ill'* is not enough: exactly how do you feel ill? You have to give the doctor more information.

  Similarly; *'my car won't go'* needs qualifying: does the engine turn over at all or does it start and then stop?

Who does the problem affect?

- Whose problem; yours or someone else's?

  In a business context, your customer.

  In a health context, your patient.

  In education, your student

  The end-user of whatever activity you are involved in.

- Can you get rid of the problem by outsourcing a solution?

  For example: *'the roof is leaking'*: so *'call the builders'*. If you do, you face another series of questions; how will you monitor the situation, how will you fund the project; can you trust your sub-contractor to deliver on time?

  If you cannot answer these questions the problem is likely to return.

NOTES:

What is the impact of the problem?

- What are the consequences?

  For example: *'Our despatches are getting later and later'*

  'So?'

  'Our customers are complaining'

  'So?'

  'They might take their business elsewhere'

  'So?'

  'Our business will suffer'

  'So?'

  'You will lose your job!' and so on.

Discover: explore the structure of the problem, find the root causes

Whilst remaining analytical you need to relax somewhat and look around the problem. Step back and try to see the 'big picture'; look at it from different points of view.

How does the problem work?

Is there some sort of internal dynamic? For example: low performance = low remuneration = low morale = low performance. How can you reverse a spiral of decline?

- Is there a string of consequences? For example: housing chains; *'I can't move in until you move out'*. How can you get the market moving?
- Can you draw a flow chart to illustrate the structure? *(Some people prefer to think visually, some people don't: try something different)*

NOTES:

The idea that there should be one single root cause to any problem comes from lex parsimoniae, (the law of parsimony) which insists that we should seek explanations which rely on the least possible number of assumptions. It is better known as Ockham's Razor (or Occam's Razor) after the 14th Century English monk William of Ockham who used the principle to shave away unnecessary suppositions in logic. A modern acronym is 'KISS'; Keep It Simple Stupid. But the principle is hard to justify rationally; it is only a rule of thumb.

In medicine there is a desire to find a unifying diagnosis to explain a range of symptoms. However an American M.D. John Hickam pointed out that 'a patient can have as many diseases as he damn well pleases'. Thus a patient reporting a headache, fever and cervical muscle spasm may be suffering from meningitis, (one cause), or may be a chronic migraine sufferer with a throat infection and a stiff neck, (three causes). The ability to choose when to apply Hickam's Dictum over Ockham's Razor is one of the reasons that Medicine is called an Art as well as a Science.

Is it simple or complex?

- How do different elements interact?

  For example: is there a knock-on effect within your organisation in terms of morale or allocation of resources?

- Obviously the larger the project the more complex it is but apparently simple problems can have complications.

  For example: *'how can I carry out market research into my new product without disclosing it to my competitors?'*

- Even the simplest of situations have snags. For example: five of us can drive to the party but if we decide to leave the car there we can only fit four in the taxi home.

What are the root causes?

- It is very satisfying to think that there is a single root cause for any phenomenon; that any proposition can be reduced to its simplest expression. However, that may be to rush to judgement. Bear in mind that an apparently complex problem might in fact be a combination of relatively uncomplicated ones, which may or may not be interdependent.

- You may find a string of single answers forming a 'tap root'; a single unambiguous cause. But each question 'Why?' may have more than one answer; each answer forming a new branch of the root network.

  For example: *'Why is there so much litter?'*

  'Because people drop it'

  'Why?'

Here we have two possible answers which we will follow in turn:

1. *'Because people don't care'*

   'Why?'

   'Because they're detached from the consequences'

   'Why?'

NOTES:

'Because they're ignorant'

'Why?'

'Because we haven't educated them'

2. *'Because there are no litter bins'*

'Why?'

'Because we haven't put any there'

'Why?'

'Because we haven't the resources to empty them'

'Why?

'Because we have other priorities'

Determine: decide how to attempt a solution

We now need to become more judgemental, fixing upon a plan of action. Is it possible for a complex problem to be broken into manageable parts?

Are the constituent parts separable or interdependent?

What are the criteria for success?

- How will you know if you have found the right solution?
- Criteria might include effectiveness, acceptability, ease of implementation, profitability, etc.
- You need to decide these now. They make up the target you are aiming at, which you will have to recall at the end of the problem solving process to judge the likely success of your potential solutions.
- In many ways you are listing the minimum requirements, for the project to proceed. *(Although we always hope to exceed our expectations)*

What are the constraints in both time and resources?

- Is it important or is it urgent? There is a real distinction. Is a stop-gap solution feasible to give you enough time to create a permanent solution? *(Sticking-*

NOTES:

One method of prioritising is to split a multiple problem into three:

- 'Things I have to deal with now',
- 'Things I have to deal with soon'
- and 'Things I can't do anything about'

In managementspeak this is triage. As with a lot of managementspeak the term is borrowed from elsewhere and should be treated with a certain amount of caution. For a start triage has nothing to do with three; it comes from the French trier – to sort or select. It is a medical term used originally in mass casualty situations such as war or civil disaster.

plasters are both cheap and effective in the appropriate circumstances: a tourniquet is sometimes an absolute necessity.)

- What can you afford to spend in terms of time and money? It is essential to set limits at this point to prevent a project spiralling out of control. *(An unaffordable solution is not a real solution, it's another problem.)* Would a cost/benefit analysis help?

What are the priorities?

- Can you set sub-goals on the way to a complete solution?

  That is: can progress be gradual, can it be step by step, or does it have to be all at once? Very often you can make the choice yourself; for example: it is possible to introduce reforms into an organisation gradually; a new product might be launched region by region.

  (But if you're building a bridge, (or an air terminal), it had better be ready once it's opened.)

- What are the consequences of partial solution?

  Partial solutions allow a cybernetic approach; being flexible enough to react to feedback, adjusting your solution if necessary. Would that help or hinder a complete solution?

By the end of this phase you should have a good understanding of the problem; its structure, its dynamics, its complexity.

You should be thinking of a plan for how to tackle it.

You should be formulating a concise definition of the problem; or definitions if you decide to break it down and solve it bit by bit.

Very often defining a problem is half of the solution; sometimes indeed it is the whole of the solution.

If, for instance, the root cause of your car's breakdown is the failure of a particular component then a solution is available 'off the shelf': you don't need to look any further, your problem's solved. On the other hand some problems are still hard to

NOTES:

"Nothing in the world can take the place of persistence. Talent will not, nothing is more common than unsuccessful men with talent. Genius will not; unrewarded genius is almost a proverb. Education will not; the world is full of educated derelicts. Persistence and determination are omnipotent. The slogan 'press on' has solved and always will solve the problems of the human race."

US President Calvin Coolidge (1872-1933)

solve even when we know the answer: the major cause of lung cancer is smoking tobacco, but implementing the simple solution (stop smoking) is a problem all of its own.

If you are unable to come up with a concise definition you have to ask whether you know enough about this problem to attempt a solution.

For example look at these statistics from the U.K. National Health Service:

- In 1948 the death rate from cancer was 16%
- In 2008 the death rate from cancer was 27%
- Conclusion: an 11% increase despite 60 years of the N.H.S. A real problem.

However, consider these figures:

- In 1948 average life expectancy was 67 years.
- In 2008 average life expectancy was 78 years.

Conclusion: the situation is more complicated than it first appears. Maybe there is more cancer than there used to be. Perhaps diagnoses have changed over 60 years. Perhaps people in 1948 used to die of other causes before they had a chance to die of cancer. Perhaps there isn't a problem at all; perhaps it's a success story. The fact is we simply don't know; we haven't got enough information to form any sort of judgment.

'Lack of knowledge concerning all the factors and the failure to include them in our integral imposes false conclusions.'

(Buckminster Fuller 1975)

If you don't have a proper understanding of a problem you don't have much chance of finding a solution. Go back and start again.

Opportunity Recognition:

Serendipity

Creative Problem Solving is always going to provide more answers than questions. Even at this analytical stage you should have found out more than you need to know about how to solve your problem.

Before moving on to look for possible solutions be sure to note down any interesting thoughts: seemingly irrelevant ideas which might be useful in other areas are the inevitable by-product of structured thinking.

An astonishingly wide range of inventions, products and discoveries are said to have been found by accident or 'serendipity'.

The list includes Penicillin, Velcro, Superglue, L.S.D., corn flakes, chocolate chip cookies, Cellophane, Teflon, the colour mauve, cyclamates, iodine, the microwave oven, the New World and even the planet Uranus.

The first use of the word serendipity was in 1754. The writer Horace Walpole coined it from a *"silly fairy tale, called The Three Princes of Serendip"* to describe discoveries made by *"accidents and sagacity"* whilst looking for something else. And therein lies the secret: these discoveries do not happen to just anyone; they happen to people of 'sagacity' who are already on the lookout for something.

In 1854 Louis Pasteur made the famous remark that chance favours the prepared mind. *("dans les champs de l'observation le hazard ne favorise que les esprits préparés")*

We cannot deny the part that chance plays in problem solving:

In a lecture in 1895 Ernst Mach observed: *"The majority of the inventions made in the early stages of civilisation, including language, writing, money,*

and the rest, could not have been the product of deliberate methodical reflection for the simple reason that no idea of their value and significance could have been had except from their practical use."

He challenges us to picture *"the genius of a man who could have foreseen without the help of accident that clay handled in the ordinary manner would produce a useful cooking utensil!"*

He also points out that of these accidents "…*unquestionably many were* ***seen*** *numbers of times before they were* ***noticed***…" [original stress]

William Beveridge has this to say:

"Although we cannot deliberately evoke that will-o'-the-wisp, chance, we can be on the alert for it, prepare ourselves to recognise it and profit by it when it comes. Merely realising the importance of chance may be of some help to the beginner. We need to train our powers of observation, to cultivate that attitude of mind of being constantly on the look-out for the unexpected and make a habit of examining every clue that chance presents."

Patsy O'Connell Sherman, the American research chemist who was responsible for turning a laboratory accident into the enormously successful fabric protector Scotchgard advised:

"Keep your eyes and mind open, and don't ignore something that doesn't come out the way you expect it to. Just keep looking at the world with inventor's eyes!"

But if there is one thing as inevitable as death and taxes it is that you will forget it unless you **write it down**.

NOTES:

Interlude

After the rigours of Problem Definition we deserve a rest. One of the hardest parts of problem solving is stopping ourselves from rushing to judgement. We need to separate the different phases of problem solving if we are to be effective. We must switch off and do something else.

The French philosopher Diderot (1713 – 1784) coined an expression, *'l'esprit d'escalier'*, to describe that feeling when you think of what you should have said, just a little too late; when you are on the stairs on the way out, with the door slamming behind you.

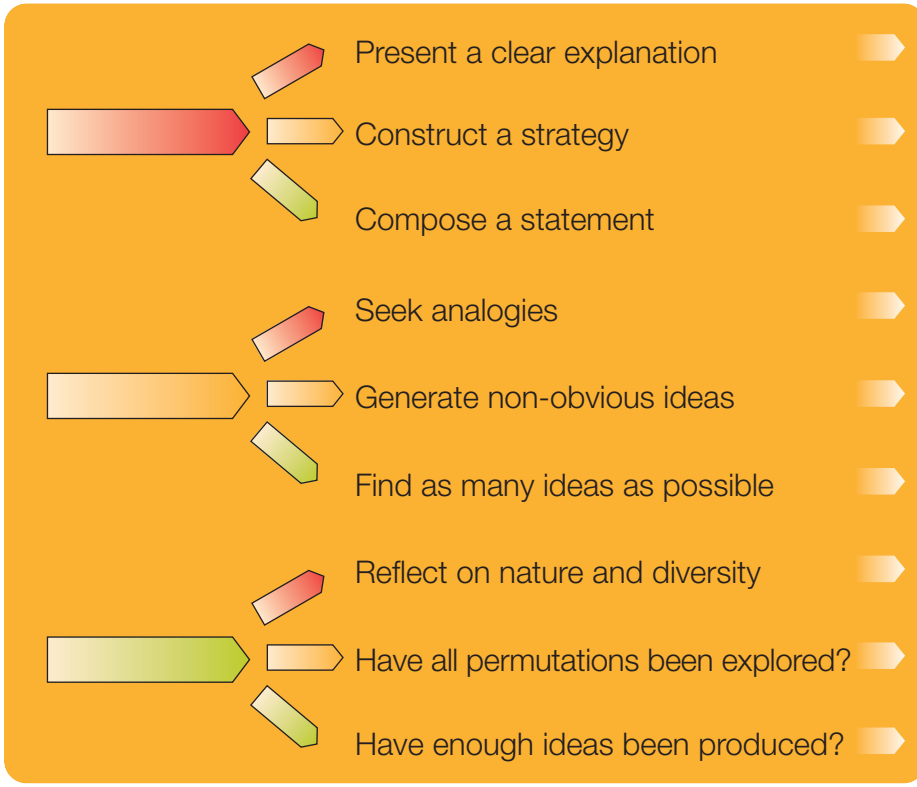
(When we 'switch off' it is usually the case that we are really on 'standby' and ideas will 'pop' into our heads when we are least expecting them.)

The notion of letting ideas incubate is not new, and the anecdotal evidence is strong. The advice when making a big decision has always been *'sleep on it'*. So as we start the next phase take time to pause then review your problem definition, if possible get someone else to review your progress. Once again this is not new: bringing 'a fresh pair of eyes' to a problem has always been good advice.

Repeat and modify as many times as it takes to make it possible to attempt a solution: *creative problem solving is an iterative process;* you can always return to the beginning.

Hopefully by this stage we have assembled the facts about our problem and we have defined the area of our opportunity; we should know where we are on the vertical axis of 'Kirk's Space'. It may be that the definition stage has pointed a direct route to a solution; the facts as revealed are enough to be arranged, or re-arranged into a solution.

But what if we are not able to re-present the situation or re-structure the problem with the facts at hand? Where are we going to look for fresh ideas?



Again the fractal nature of the problem solving process means that we start from the focussed problem statement; going into the deliberately unfocussed, fuzzy generation of as many ideas as possible, before starting to draw these together into possibilities.

Phase Two: Discovery

"A great discovery solves a great problem but there is a grain of discovery in the solution of any problem."

George Pólya (1887 – 1985)

This section is more relaxed. What Guilford identified as divergent production, generating multiple solutions. Exploring broadly; gathering ideas as widely as we can. The style of thinking some people associate with the right hand hemisphere of the brain. How might we get to where we want to be?

By now we should have a 'deeper' knowledge of our problem. If we think of depth of knowledge as a vertical axis, then we are going to look for fresh ideas along the horizontal axis, breadth of knowledge. Of course vertical pre-eminence counts for nothing on the horizontal axis; we are going to find shallow and half-understood concepts. Although expert knowledge is always welcome at this stage it is not all that important.

"I may here remark that I have always adopted a different reading of the old proverb, 'A little knowledge is a dangerous thing'; this may indeed be true, if your knowledge is equally small on all subjects; but I have found a little knowledge on a great many different things of infinite service to me."

Inventor and entrepreneur Sir Henry Bessemer (1815 - 1898)

Thinking outside the box: With Hindsight it makes Perfect Sense

There is no obvious connection between the most extravagant sport in the world and caring for sick children. Nevertheless two heart surgeons at Great Ormond Street Hospital for Children spotted an analogy between their work and what they saw happening in Formula One. Professor Martin Elliott recalled: *"We just realised that the pit stop where they changed tyres and topped up the fuel was pretty well identical in concept to what we do in handover—so we phoned them up."*

(Handover is the procedure whereby patients are transferred from one team of experts in the operating theatre to a different team of experts in intensive care)

Dr Alan Goldman explained what followed: *"Initially we went to the McLaren team and then later on we also worked with Ferrari. We spoke about leadership and how to organise the process; who was in charge, rhythm, task allocation, checklists, all of which aren't well embedded into medicine. They were all very simple things, but they were just not part of our culture."*

A telling moment came when one of the Ferrari team asked the seemingly innocuous question 'who is in charge?'

The result of the collaboration was the wholesale restructuring of handover protocols when transferring patients from the operating theatre to intensive care, integrating a clear chain of command, detailed checklists and clear contingency plans. Since introducing the new process handover errors have halved.

The F1 pit technicians did not tell the doctors what to do – they simply showed them how they organised a team to work quickly, quietly and efficiently under intense pressure: a straightforward, if not immediately obvious analogy.

During this non-judgemental idea gathering phase we are searching for material which we will bring back into our areas of expertise to build into our own solutions to be assessed on our own terms. If we try to leap from one height to another we may fall, but bearing in mind that we are 'pre-concept' we have nothing to lose, we might even enjoy the trip!

Define: Prepare to find solutions

This section is actually a final iteration of the last section of phase one: making sure we all understand exactly what we are looking for. It sets the agenda which we are going to follow through the rest of the process. To use that over used and little understood expression this is where we define *'the box'* that we are going to *'think outside of'*.

Present a clear explanation of the problem.

- Are the constituent parts separable or interdependent?

Construct a strategy to tackle the problem.

- Is it possible for a complex problem to be broken into manageable parts?

Compose a short, concise statement of the problem or part of the problem which is to be addressed.

- For complex and multiple problems you will need to prioritise the constituent parts and address each in turn with a separate problem statement.

Discover: Generate multiple solutions

This is the creative filling in the problem solving sandwich.

"Intelligent people can juggle a half-dozen concepts simultaneously and make good decisions rapidly – and many of them seldom have a creative moment. They are so good at the standard answers and so eager to move on to the next decision that they never play around with non-standard possibilities….There is such a thing as

NOTES:

"It is a favourite popular delusion that the scientific enquirer is under a sort of moral obligation to abstain from going beyond that generalisation of observed facts which is absurdly called "Baconian" induction. But anyone who is practically acquainted with scientific work is aware that those who refuse to go beyond fact, rarely get as far as fact; and any one who has studied the history of science knows that every great step therein has been made by the "anticipation of Nature", that is by the invention of hypotheses, which, though verifiable, often had very little foundation to start with; and, not unfrequently, in spite of a long career of usefulness, turned out to be wholly erroneous in the long run."

British scientist T. H. Huxley (1825 – 1895)

being 'too good' because, in much of life, there are no correct answers. You have to invent new ones and contemplate them for some time." W.H. Calvin (A Brief History of the Mind, 2004)

Both for individuals and organisations rigid adherence to 'standard answers', the assumption that what has worked in the past will work in the future, not only encourages stagnation, it leaves us vulnerable to disruptive innovation from outside. If we are not exploring 'non-standard possibilities' we can be certain that someone else is. To paraphrase Schumpeter: *'nothing avails against the creative response'* (whether we like it or not!)

Some might say that in certain domains, science for example, there definitely are 'correct answers' and so there is no room or need for creativity; all we have to do is uncover the truth step by step. However, as William Beveridge writes: *"It is scarcely possible to foresee a discovery that breaks really new ground, because it is often not in accord with current beliefs."* To formulate his hypothesis the scientific investigator has to take an imaginative leap:

"for usually discovery is beyond the reach of reason."

And so we have to ask whether everybody can be creative, exactly where do new ideas come from, and just what do we mean by creativity.

"…although Mozart was a super human he was not super-human. We are all creative to some degree…"

(Margaret Boden 'The Creative Mind' 1990)

We have already demonstrated that we all use our imagination to create new concepts from old in our everyday thinking. Let's start by again dismissing the idea that 'creatives' are 'special people'. A very simple example will demonstrate that we are all 'creatives'.

We all know that we should engage our brains before opening our mouths, but we rarely do. When we start to speak we seldom have any real idea of how the sentence is going to end, or even *if* it is going to end. We may set out with a plan in mind, but in conversation, even with ourselves, we are constantly subject to interruption.

A new idea from two old ideas:

1. The idea of transporting people or goods by placing them in a container and then moving that container is as old as the first wagon, sled, boat or papoose.
2. The earliest reference to the phenomenon of magnetism comes from China in the 4th century B.C.

These two very 'old' ideas collided in the 1960s under the guidance of engineer Eric Laithwaite (1921 -1997) and created what became the Maglev transportation system.

The Maglev is so novel that it we have difficulty describing it: whilst running it is not in contact with the ground, and yet is not an aeroplane. Hovercrafts were similarly problematic, car, plane or boat? The hovercraft has a pilot whilst the Maglev has a driver.

Maglev train coming out of the Pudong International Airport in Shanghai

We revise what we might have been going to say as we see other people's reaction. This feedback loop makes our speech cybernetic; one of the most significant stages of child development. *(And of course sometimes we just tail off into inconsequence from lack of interest, other people's as well as our own.)*

We are all making it up as we go along; this is proven by the fact that we can usually tell when someone isn't. From cheesy chat-up lines to sales patter, we recognise when something is unoriginal or too contrived.

"creativity is an all-pervasive feature of everyday language. …. Linguistic creativity is not simply a property of exceptional people but an exceptional property of all people." Ronald Carter (Language and Creativity 2004)

So creativity is there every time we open our mouths. **We are all creative.** We have all acquired some of that tacit capability, that 'know-how'. With practice and the acquisition of a greater vocabulary we are all able to create bigger and better sentences.

The American advertising 'creative' James Webb Young admitted that he was not 'special', asserting *"…that the production of ideas is just as definite a process as the production of Fords; that the production of ideas, too, runs on an assembly line; that in this production the mind follows an operative technique which can be learned and controlled; and that its effective use is just as much a matter of practice in the technique as is the effective use of any tool."* 'A Technique for Producing Ideas' (1940)

So let's look at where ideas come from. Taking our cue from Werthenheimer, we realise that all new experiences resonate in our memories of old experiences.

'New ideas' are made out of 'old ideas'.

This is not to say that there is nothing new under the sun – the ideas and concepts which we judge to be most creative are those for which we can see no precedents, and yet are most applicable to the present. So as far as definition goes let's agree with the general consensus that 'creativity' has to be both novel and appropriate.

NOTES:

"Ainsi Presque tout est imitation… …Les esprits les plus originaux empruntent les uns des autres." (Almost everything is imitation… …the most original minds borrow from one another.)

Voltaire (1694-1778)

As is obvious with linguistic creativity, an increased (and ever increasing) vocabulary gives the speaker a greater resource to draw from and gives them the opportunity to form new and more appropriate language.

So let's see how we can increase our vocabulary of ideas.

Seek analogies from other domains

If there is a secret to creativity it is this: We are not limited to our own experiences; we are not limited to our own minds. It is our minds which reach out and seize 'inspiration'; not the other way round: we are the motive force behind 'ingenuity'. From this standpoint we can either sit around waiting to take hold of 'inspiration' if it floats by, or we can go looking for it. We can search other people's minds, other people's experiences and even consider other species.

We have pointed out the importance of tacit knowledge and knowing and the difficulties associated with passing on such capabilities, but it is the ability to pass on explicit knowledge which is one of the distinguishing characteristics of humanity. Each successive sophistication in society is accompanied by sophistication in communication: the development of language, then writing, then printing, has increased the sum total of ideas exponentially. *(The Internet now offers more ideas than we can possibly cope with, giving us the chance to be not only extremely well-informed but also completely wrong at the same time.)* So we have a lot to look at.

- A similar problem to yours may have been successfully solved in an entirely unrelated field. Both George Polya (mathematics) and Genrich Altshuller (engineering) emphasise the importance of analogy; reasoning that all problems are solvable by moving from a specific problem to a general problem; achieving a general solution before returning with a specific solution.

Say for example you run a small bakers and sandwich makers. Every lunch time the line of people reaches out of the shop blocking the pavement. The neighbouring shops don't like it but 'so what?' they're just jealous, they'd love to have a problem like yours. On the other hand you are so busy that customers are walking away because the queue is too long. You have taken your problem through Phase One

NOTES:

W.H.Calvin *('A Brief History of the Mind')* quotes Galileo rejoicing in the I.T. of his day: *'But surpassing all stupendous inventions, what sublimity of mind was his who dreamed of finding means to communicate his deepest thoughts to any other person, though distant by mighty intervals of place and time! Of talking with those who are in India; of speaking to those who are not yet born and will not be born for a thousand or ten thousand years; and with what facility, by the different arrangements of twenty characters upon a page!*

very quickly, the root cause is obvious, it's the lunchtime rush! That is the specific problem, so let's identify the general problem. Again it is quite easy, the name gives it away, it is the rush, simply a surge in demand. You could respond in classic fashion by increasing supply (getting more staff and a bigger shop) or reducing demand (putting up your prices). But if you want to be a little more imaginative you should look for analogies; responses to the general problem of surges are many and varied. How do power companies deal with the millions who all decide to boil a kettle during half time of the World Cup Final? How do the authorities deal with rivers that are prone to flooding? For that matter how does an unmanaged river respond to flooding?

What do Santa's elves do during the summertime? And very soon you start to see similarities. Could you increase your staff with part-timers or by redeployment; could you even increase your shop space temporarily? Rather than letting them overflow, could you control your tide of customers by speeding up the queues? You could alter your prices so that the need for change was reduced, or have a 'crawler lane' for large orders. Could you reduce the peak of demand with pre-ordering or even delivery? Very soon you will find you have an array of possibilities from which to construct *specific* solutions.

- Ask yourself how your problem would be solved in another time, another place. Is it a problem of communication? Is it a problem of capacity? If your problem is organisational, look at other forms of organisation. If it's structural, look for other structures.

The plant kingdom famously gave George de Mestral the idea for what became Velcro. More recently Speedo developed their Fastskin swimsuits with reference to sharkskin. Anthills and termite mounds have provided insights into air-conditioning.

(A word of warning: an analogy is a similarity in some respects, not all respects: you should not take them too literally. An easy example of this is the 'business is war' analogy. Managers who study Sun Tzu and Machiavelli are on the right track but are woefully narrow-minded in being bound to a single analogy. Machiavelli may have been appropriate in Renaissance Europe, but is he really that universal?

NOTES:

"The key to success is to risk thinking unconventional thoughts. Convention is the enemy of progress. As long as you've got slightly more perception than the average wrapped loaf, you could invent something"

Inventor Trevor Baylis (Born 1937)

Why the obsession with Sun Tzu? What about Clausewitz? Why is Napoleon more glamorous than Wellington? Why limit yourself to humans? You should be looking for models in the full range of competition, from sports to epidemiology. The other thing to remember about analogies is that you can abandon them whenever you like: they are merely a source of old ideas which you might be able to re-structure and re-present as new ideas appropriate to your situation.)

Generate non-obvious ideas

As we said, the secret to creativity is that we are not limited in our search for material. We are not even limited by reality, we are able to go beyond the facts: imagination is just that; forming in our minds-eye things which do not even exist, (yet.)

- So called 'off the wall', 'out of the box', 'lateral' thinking is not new; every joke or riddle relies on looking from a different point of view.
- If you want to generate lots of extraordinary ideas, simply take an ordinary idea and tweak it. Turn it inside-out and upside-down; reverse it, modify it; break it up and mess around with the bits; substitute, remove or add new parts; re-combine it in a different way. Introduce totally random elements. 'Hitch-hike' on each other's ideas; go one step beyond. Imagine the perfect solution. How could you achieve the direct opposite of what you want?
- Classic 'brainstorming' as developed by Alex Osborn advises a few basic rules: suspend your disbelief, check your ego at the door, don't criticise; don't judge; *(If you're laughing it's working)*; keep it short, you can always try again. **Write it down!**
- For the moment we are concentrating on quantity rather than quality: wild ideas are more than welcome.

Find as many ideas as possible

- Don't forget the obvious.
- Don't forget past solutions which became redundant; circumstances may have changed.
- Explore to the edge of that bell curve of normal distribution.

NOTES:

MSc Students 'storming' at UNIEI

Switch off and take a break. **This is absolutely essential**, even though it is sometimes the hardest thing to do. Incubation is the key to hatching good ideas.

Idea generation is one of those areas of tacit knowing where there is a limit to explicit instruction. As we said in reference to swimming, 'you have to get your feet wet'. However, the next best thing to doing it yourself is watching someone else splashing around in the pool of ideas. So here is an account of idea generation and evaluation of the type currently practiced by the authors through the University of Nottingham Institute for Enterprise and Innovation.

Students were formed into groups, no less than four, no more than eight, and given problem areas in which to look for entrepreneurial opportunities.

One group of students were looking for opportunities to reduce traffic congestion in a medium sized city in the U.K. At the end of the problem definition stage, one of the root causes they had identified was that there were only 5,500 parking spaces in a city with 250,000 cars. They took this as a starting point for Phase Two: Discovery.

This storming session was held in a large room along with other teams working on their own projects.

Pens, paper, flipcharts etc. were provided in abundance.

Apart from the problem statement all the paper was blank.

The students had all worked together previously and so were relaxed in each others company.

An egalitarian atmosphere prevailed with each member at some point naturally taking the role of 'penholder' for the group.

After 30 minutes or so the ideas and the laughter tailed off and so they stopped and took a coffee break.

Overleaf are a few of the ideas generated in the first storm session:

image source www.wordle.net

More parking; less parking; underground parking; ***underwater parking****;* parking in the park; ***cut down all the trees****; park in the sports stadium; park in the middle of the road;* park on the sides of buildings; *stackable cars; disposable cars; multi purpose cars; giveaway cars;* **white bicycles***; miniature cars;* foldaway cars; *free car parks;* expensive car parks; *auction parking places;* **Ebay parking places***; valet parking;* time-share car parks; *swap parking places;* ***rent out your driveway****; mobile car parks; ban driving;* ban pedestrians; *ban city centres;* ***flexible opening****;* flexible working; flexible shopping; *ban working;* ***work from home****; shop from home; remove the need for travel;* better communications; **better video to find places***; G.P.S.; automatic space utilisation;* ***more taxis****;* personal taxis; corporate taxis; *more trains; more buses;* ***more bicycles/skateboards/unicycles****; park and ride;* ride and park; *no lines in car parks;* narrow lines in car parks; ***floating cars****; abandon your car;* driverless cars; *homing cars;* **whistle for your car***; intelligent car parks; lower roofs in multistories; transformers;* expandable car parks; *mobile car parks; car racks;* ***jigsaw cars****; Ford only parking;* odd number plates; *lottery tickets for parking;* mobile offices; *work in your car;* ***wi-fi in the traffic jam****; penalise large cars; ban deliveries; cheap night shift parking;*

ban lorries; ban buses*; ban everything.*

It reads like a stream of consciousness, which it is, the consciousness of the group as they bounce ideas around, adding, subtracting, reversing and hitch-hiking: we will return to them later.

NOTES:

Students constructing possibilities

Determine: realistic concepts begin to emerge

As Linus Pauling observed, one must *"have lots of ideas and throw away the bad ones….You aren't going to have good ideas unless you have lots of ideas and some sort of principle of selection"*. By now you should have generated lots of fuzzy ideas; this is the time when we refocus and start drawing together possibilities.

Reflect upon the nature and diversity of those ideas

- Once more beware of rushing off with the first solution you find; it is unlikely to be a perfect fit. It's better to have a range of possibilities to choose from.

Have all the permutations and combinations been explored?

- What happens if you 'force-fit' two or more concepts?
- Can you deconstruct obvious concepts and put them back together in a slightly different way?
- Can you randomise your ideas?

There are lots of Internet sites which can be used to alter a piece of text: forming it into graphics, or even constructing poetry.

Have enough ideas been produced for novel concepts to emerge?

- Every idea can be taken one step further, simply by applying an additional brainstorming heuristic; addition, subtraction, reversal etc.
- Use the Internet to translate your ideas into another language and back again; words appear that are not quite the same as the ones you used originally. For example: the students' word 'ban' came back as 'prohibition' setting off a new train of thought.

Novelty is not that difficult; it is *appropriate* novelty we are after.

Our students 'threw their ideas into the air' several times before their wilder ideas began to combine into something more concrete: possibilities.

To emphasise once more: creative problem solving is an iterative process – you can repeat it as many times as it takes. But if you are still getting nowhere you may need to reassess your original definitions i.e. start right back at the beginning.

Opportunity Recognition:

Problem Finding

We have suggested that keeping a 'prepared mind' enhances our ability to recognise opportunities when they occur. If we recall Beveridge: *"although we cannot deliberately evoke that will-o'-the-wisp, chance, we can be on the alert for it, prepare ourselves to recognise it and profit by it when it comes"*.

But it might be possible to improve the odds further by deliberately searching for the situations where happy 'accidents' can be made to happen; seeking out the 'target no one else can see' , in other words *problem finding*.

We mentioned that UNIEI students are expected to place themselves in the bottom left-hand corner of Kirk's Space – where *'we know there's a problem but we're not quite certain what it is and we are not especially sure how to solve it.'*

Problem finding has to be done one stage earlier – indicative of the entrepreneurial spirit: *'that which identifies and creates opportunities and then takes actions to realise new ideas in an appropriate market in such a way as to bring value to that domain.'*

At UNIEI we assess such opportunities by asking questions like:

'Is this a real problem?' 'Will anyone pay for a solution?' 'Can you make a good job of it?' 'Can you make a return on your investment?' 'Is the solution sustainable?' – In short *'Is this a problem worth solving?'*

Problem finding is quite distinct from problem solving. As we saw in 'definition', with problem solving we can borrow established analytical techniques from other domains.

From the police – a crime has been committed. From the news media – an event has occurred. From medicine – the patient presents symptoms. In situations like these we can investigate, we can drill down, we can attempt a

diagnosis - we have some sort of point from which to proceed, even though that point will change as our understanding of the problem deepens.

But what is our starting point to be? How can we set about looking for trouble?

One way would be to generate a mass of ideas and concepts by deconstructing a problem area using the techniques described in 'discovery'. Then examine this database – remember the car park full of cars on page 15. A full understanding of the array is only achieved by looking at it from all different angles, colours, manufacturers, engine sizes, number of doors etc.

And once again we find analogies. This is reminiscent of a technique from anthropology: *"Multi-sited research is designed around chains, paths, threads, conjunctions, or juxtapositions of locations…"* ('Ethnography in/of the World System: The Emergence of Multi-sited Ethnography' George E. Marcus 1995)

Marcus suggests a series of heuristics: *"Follow the People; Follow the Thing; Follow the Metaphor; Follow the Plot, Story, or Allegory; Follow the Life or Biography; Follow the Conflict"*. The aim is to establish a 'rapport' with the communities to be studied.

These are heuristics for ethnographers; but there is no reason why others could not be tailored to any area. Detectives investigating crime are told to *'follow the money'*: we can do the same – *Follow the market; Follow the producers; Follow the consumers: Follow the leaders; Follow the followers etc*.

Establishing a rapport with the problem area by identifying all of its *'chains, paths, threads, conjunctions, or juxtapositions'* should help would be entrepreneurs to differentiate real from perceived problems – to identify those which are worth solving.

As we said right at the outset of this book most of us have the luxury of seeing problems as opportunities, and many of us enjoy the further luxury of choosing which problems/opportunities we care to address. And that is the essence of entrepreneurial thinking.

NOTES:

Interlude

Whilst we wind down from our idea generation, it's worth re-examining our definition of 'creativity'. 'Novel' and 'appropriate' were the keywords. But it is only when we actually apply a new idea that we can make a judgement as to whether it is appropriate or not. Until that time our 'creative genius' remains theoretical.

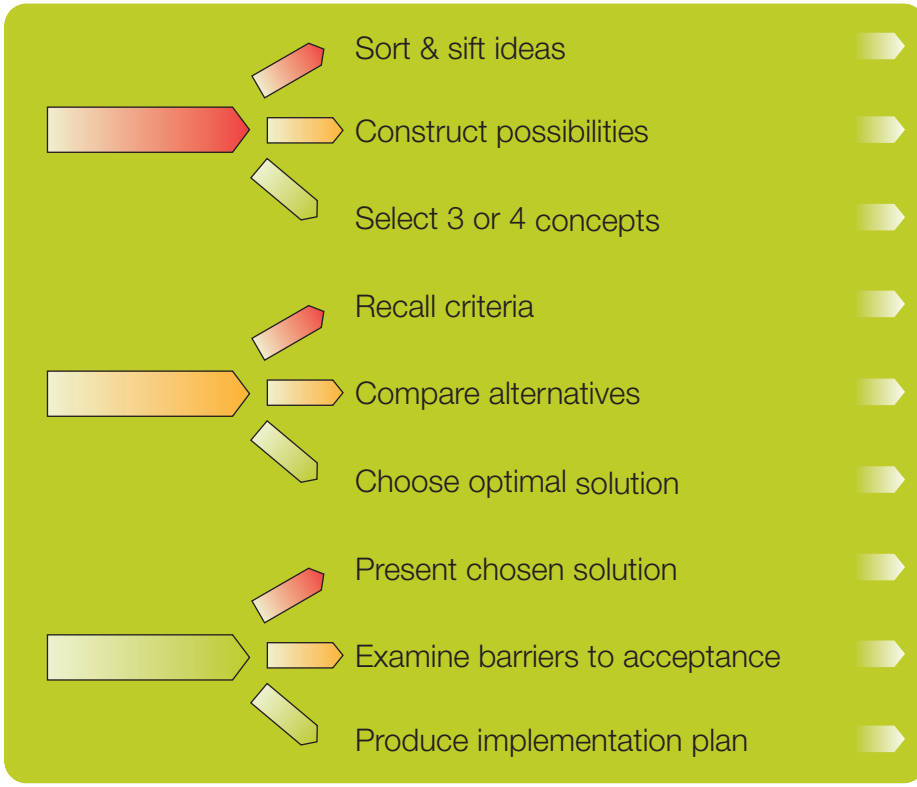
And so we can go further with our definition:

'creative ideas have to be new, appropriate, and applied.'

We can of course assess our new ideas by applying them straight away; by simple trial and error. Trial and error might well be the easiest way of testing in some circumstances, but most of the time we need something better than that headlong rush to judgement. As we all know hindsight is a wonderful thing, so what we need is a little foresight.

To recap, the model of consciousness in which we are applying our problem solving process is one in which we continually perceive new experiences in the light of past experiences. When faced with the unfamiliar we immediately look for something similar that we are familiar with. We live in this sense in what neuroscientist and Nobel Laureate Gerald Edelman called 'The Remembered Present' (1990).

To take this one step further, whilst we are in the phase of productive thinking, re-presenting, re-structuring our ideas, we surely also live in an *'imagined future'*. Imagining what may happen when we finally get around to applying our ideas is the third and final stage of our problem solving process



The final stage of our problem solving process exhibits the fractal nature of the whole. Although convergent thinking is dominant, there is a significant element of divergent thinking which encourages the creative modification of possibilities to ensure the most appropriate solution.

Phase Three: Determination

Determination: not only in the sense of judgement; determining the best solution, but also in the sense of resolve; the determination to go ahead with more certainty that we have identified the optimal rather than the acceptable.

This section is all about re-focus and synthesis; engineering the ideas from phase two into practical, realistic possibilities, and then assessing them. The strategies we adopt should be both pragmatic and attainable.

Evaluating possible solutions rigorously is critically important; there is no point in coming up with creative, imaginative ideas which are totally impractical.

Define: Select and engineer potential solutions

This is a final iteration of the last section of Phase Two; again setting the agenda for what is to follow. Preparation should be the arrangement (and rearrangement) of possibilities from the previous phase into concepts which are capable of evaluation.

Sort and sift ideas into categories

The categories chosen will reflect what was discovered about the problem way back in Phase One. For example bottom-up or top-down; gradual, step by step or all at once; stop-gap or permanent; hi-tech or lo-tech; top-price, mid-price, or budget, and so on.

Another Cautionary Tale: The WoBo

Sometimes an idea seems so self-evidently brilliant that we can see no reason why we shouldn't just get on with it, especially if we are rich enough and powerful enough to make it happen: On a trip to the Caribbean in the early 1960s the brewer Alfred Heineken noticed two things; firstly that the poor people of the islands made shanty towns out of anything they could find; and secondly that the beaches were littered with beer bottles (many of them his).

Back home in Holland he and architect John Habraken launched a project to design a bottle with a secondary use as a brick. The WoBo (World Bottle) went through several prototypes before it was finally shelved as impractical.

So why would such an elegant and simple concept fail? And might it be worth reviving in these eco-sensitive times?

- In the nineteen-sixties glass bottles were much thicker than today. In fact most bottles were cleaned and re-used by the bottling plants.
- At least two different sizes had to be produced to turn corners and build windows and doors, without having to cut the bottles.
- You would have to drink an inordinate amount of beer to build even the smallest shack.
- People who are reduced to scavenging building materials rarely have the money to buy the mortar needed to fix the bottles together.

Finally, would YOU like to live in a beer-bottle house?

The English writer and critic G.K. Chesterton (1874 – 1936) said: *"Art is limitation; the essence of every picture is the frame"*. Although we have been looking for solutions 'outside the box' remember that those solutions must fit 'back in the box', within the frame of constraints we set ourselves earlier on. If our ideas are so revolutionary that they break the frame then we will have to take special care when planning how to introduce them.

Construct realistic possibilities

- Separate good *ideas* from *lots of ideas*.
- *Quality* rather than quantity.

Select three or four different concepts for final evaluation

Whilst the emphasis is on the practical and pragmatic we should not be afraid to properly assess seemingly eccentric ideas. That's what creative problem solving is for.

Let's revisit our students with 45 cars for every single parking place. They reconvened the next day and decided to sort and sift into hi-tech solutions, lo-tech solutions, and those requiring a degree of social engineering. (Remember that these students were looking for entrepreneurial opportunities and so had a far wider frame of reference than many of us who are looking for specific solutions within quite narrow constraints.) Some ideas fitted into more than one category. For each of these categories they selected and refined one possibility to examine in detail.

Their lo-tech possibility was the mobile car park: once full, the car park would be removed until the end of the day.

The hi-tech solution was yield management of car parking: the car park would match subscribers to empty places using wireless technology, essentially linking a central database to individual's satellite navigation systems.

The solution which would require social engineering was to ban all heavy goods vehicles and other non-commuter traffic from the city centre during designated hours.

Discovery: investigating the alternatives; finding the best solution

This is rigorous analysis across the breadth of possibilities.

London Sept. 19. 1772

Dear Sir,

In the Affair of so much Importance to you, wherein you ask my Advice, I cannot for want of sufficient Premises, advise you what to determine, but if you please I will tell you how. When these difficult Cases occur, they are difficult chiefly because while we have them under Consideration all the Reasons pro and con are not present to the Mind at the same time; but sometimes one Set present themselves, and at other times another, the first being out of Sight. Hence the various Purposes or Inclinations that alternately prevail, and the Uncertainty that perplexes us. To get over this, my Way is, to divide half a Sheet of Paper by a Line into two Columns, writing over the one Pro, and over the other Con. Then during three or four Days Consideration I put down under the different Heads short Hints of the different Motives that at different Times occur to me for or against the Measure. When I have thus got them all together in one View, I endeavour to estimate their respective Weights; and where I find two, one on each side, that seem equal, I strike them both out: If I find a Reason pro equal to some two Reasons con, I strike out the three. If I judge some two Reasons con equal to some three Reasons pro, I strike out the five; and thus proceeding I find at length where the Ballance lies; and if after a Day or two of farther Consideration nothing new that is of Importance occurs on either side, I come to a Determination accordingly. And tho' the Weight of Reasons cannot be taken with the Precision of Algebraic Quantities, yet when each is thus considered separately and comparatively, and the whole lies before me, I think I can judge better, and am less likely to make a rash Step; and in fact I have found great Advantage from this kind of Equation, in what may be called Moral or Prudential Algebra. Wishing sincerely that you may determine for the best, I am ever, my dear Friend,

Yours most affectionately

B Franklin

Recall your criteria from the problem definition stage

Because we have, hopefully, been exploring the widest range of options it is once again essential to confirm that we are proposing to solve the problem we originally identified, within the constraints that we set ourselves.

This is the point at which so many projects go awry. Finding a solution to a different problem is not necessarily a *bad* thing, but it is a *different* thing. It might well be a great opportunity. For instance, you may have found a likely looking solution which far exceeds your expectations but also exceeds the budget constraints you set yourself. Recalling that cybernetic aspect of commonsense reasoning; the ability to revise your decisions as better information becomes available; you can either return to the beginning of this whole process with a new problem definition – *'how can we increase our budget to realise the enormous opportunities of our fabulous new concept'* – or you can carry on full steam ahead trusting that enthusiasm is a substitute for sound finance. It is surprising how often people choose the latter – remember we are still at the pre-concept phase; we are not committed to anything.

Compare the alternatives

Easier said than done; again one of the points at which we are liable to make mistakes: we have to assess the choices as dispassionately as possible. Evaluation by a group rather than an individual should be more detached but runs the risk of agreeing upon a lowest common denominator.

There exists a wide range of formal decision making tools which allow you to examine cost/benefits and impact. Dependent upon the nature of your problem some may be more suitable than others. In essence most are variations on the method described by Benjamin Franklin in his letter to Joseph Priestley. Franklin's 'Prudential Algebra' is not a simple comparison, for and against, he insists upon weighting each pro and con, and compiling his list over several days recognising that *"all the reasons pro and con are not present to the mind at the same time"*. (Lest it be thought that Franklin was over-cautious it should be remembered that anyone who flew a kite in a thunderstorm and signed the American Declaration of Independence ought not to be described as 'risk averse'.)

NOTES:

UNIEI students refining and assessing their ideas.

The Pugh Method is a technique that compares a number of new concepts against the best existing solution. It can be used to choose the top solution of several rival complete concepts, but can also be used iteratively to refine and develop proposals until a superior solution emerges with all negatives removed. The method helps to reach a consensus without the compromise often associated with group decision making.

There is no reason why you shouldn't run your solution through several different matrices; e.g. the Pugh Method, Decision Tree and Paired Comparison; if they agree, all well and good: if they disagree, perhaps you need to think again.

If by this stage your problem is not resolved you must return to an earlier point, right back to the beginning if necessary. But remember we are still pre-concept: our only commitment has been brainpower.

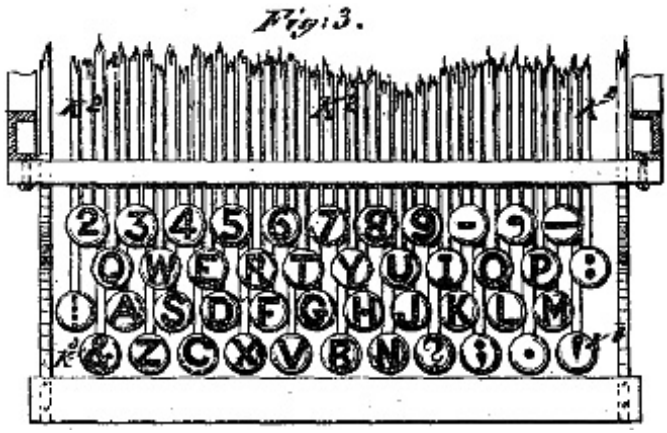
Choose your optimal solution

- Recall the distinction between the optimal and the acceptable.
- How do the solutions match up to your goals?
- Which solution has the most realistic chance of success?

Now is a good time to take risk into account. And here we see a curious misunderstanding: just because innovators and entrepreneurs take risks does not mean that all risk-takers are entrepreneurs and innovators: it's an example of one of the oldest logical fallacies in the world.

> *'To understand successes, the study of traits in failure need to be present. For instance some traits that seem to explain millionaires, like appetite for risk, only appear because one does not study bankruptcies. If one includes bankrupt people in the sample, then risk-taking would not appear to be a valid factor explaining success.'* Nassim Nicholas Taleb (2004)

There is a difference between calculated risk and mere gambling. Taking the time, as we have, to examine problems and possibilities at this stage should reduce the chance of failure, but it will never be removed completely. Acceptance of risk necessarily implies the inevitability of occasional disappointment. And here is one of the sadder aspects of innovation; the best ideas are not automatically accepted.



Qwerty layouts from the original 1878 typewriter patent drawing…

…to a 2004 X-Box controller.

Some domains are extremely resistant to change. This is not just innate conservatism. Some technologies have paths of dependency which are very difficult to alter; for example the QWERTY keyboard. Some companies, for example Microsoft are so dominant that it's hard to see how new independent products can make inroads.

And lastly some products seem to have achieved a level of perfection of form and function that allows them to shrug off radical innovation. The bicycle looks virtually the same as when it was invented, despite the fact that incremental improvements have altered every part of it. As a cheap method of personal transport it reigns supreme.

To return once more to our car parking example: Over several iterations with changing criteria the students assessed their alternatives using a simple advantage/disadvantage matrix. Their judging criteria formed the rows; the solutions were the columns. Each cell was then marked plus, minus or not applicable.

CRITERIA FOR SUCCESS	POSSIBLE SOLUTIONS		
	Mobile car park	*Banning heavy traffic*	*Intelligent yield management*
Start up cost	+	+/-	+
Market potential	+	*NA*	+
Profitability	-	*NA*	+
Acceptance by consumers	+	-	+
Acceptance by government	+	-	+
Complexity of implementation	+	+	-
Acceptance by existing suppliers	-	-	+
Effectiveness to solve the problem	-	+	+

As the final table shows, the high tech solution scored highly and was chosen as the one to be taken forward as a concept whose implementation can be planned with a very real chance of success.

POSSIBLE SOLUTIONS

CRITERIA FOR SUCCESS	*1*	*2*	*3*

POSSIBLE SOLUTIONS

CRITERIA FOR SUCCESS	*1*	*2*	*3*

Advantage / disadvantage matrices

With the benefit of hindsight we can look back at the array of brainstormed ideas and trace the development of successful concepts, but that is to misunderstand the nature of idea generation. The most creative solutions emerge from a range of possibilities in a manner which cannot necessarily be forecast.

It is worth recalling that there may be no single, 'correct' answer to any given situation. It must have been a similar array of ideas which led M.I.T. to propose their City Car: a shareable, re-chargeable, *stackable* solution to the same problem that the students were addressing.

Determine: looking to the future

This is the final part of our problem solving process. After all that exploration and wandering around we have to re-focus our minds and concentrate on that 'imagined future'.

Present your chosen solution as a clear proposal

- Your solution may exceed your criteria for success or it may only be a partial solution: does this affect the resources you need? Do you need to return to the beginning with a re-phrased Problem Definition?

Examine possible barriers to acceptance

Remember we are not in a vacuum and every action will cause a reaction. Change is nearly always resisted in one way or another; usually in a wholly predictable manner. If your plan fails to convince it is not the fault of those it fails to convince; it is *your* plan and *your* failure.

- If you are in any kind of business you will have competitors; how will they react?
- How can you safeguard your investment?
- How will the solution affect you and your organisation?
- How can you 'sell' your solution to your colleagues?
- How can you 'sell' your solution to the wider public?
- How will you adapt to the new situation?

NOTES:

"We learn wisdom from failure much more than from success. We often discover what will do, by finding out what will not do; and probably he who never made a mistake never made a discovery."

Samuel Smiles (1812-1904)

- Can you control the impact and response as your solution is applied?
- How will you monitor implementation?
- Have you the resources to cope with likely obstacles?
- Will you have the flexibility to react to feedback?
- Have you a plan 'B' or even a plan 'C'?
- Could you cope with runaway success?

Produce an implementation plan

We have already accepted the chance of failure, but in the knowledge that failure is always more expensive further on down the road: *minimising* that risk constitutes 'foresight'.

The implementation plan should represent determination and resolution in both senses; as a final expression of this process and as the first step in the next.

At the end of this stage you should have a practical response to the questions posed by your problem definition. If not, re-frame, re-structure or split your question into parts and start again.

So what now? All you have to do is put your idea into action - easy. No, actually this is where the real work begins. But consider this: by going through a structured thinking process at the 'pre-concept' stage of innovation you should have achieved the following:

- A deeper understanding of the situation, be it problem or opportunity.
- A wider exploration of the possibilities.
- A practical prospect of success: a realistic 'imagined future'.

As we pointed out near the start of this book the greatest resource that humanity possesses is the human mind. It is readily available, inexhaustible and free at the point of use. All it takes is a little time; time which we can borrow from the countless hours and days we waste dealing with avoidable errors.

'It may be the early bird that gets the worm but it's the second mouse that gets the cheese' Anon.

Opportunity Recognition:

The Driving Force of Innovation

We started this book with a somewhat pessimistic observation that we are only staying ahead of catastrophe by our ingenuity, which might suggest that all innovation is driven by demand: problems are solved simply because they need to be solved. Which leads people to assume that they will not be solved until that need is expressed – 'necessity is the mother of invention.'

"Only a crisis—actual or perceived—produces real change."

Milton Friedman: Capitalism and Freedom (1962)

But no-one bounds from crisis to crisis – they lurch. We know that crisis engendered decisions are sub-optimal, many of them are rushes to judgement driven more by a lowered risk aversion than by genuine appropriateness. The main opportunities in a crisis are for opportunists – those who will bring *their* solutions to your problems and probably charge you for the privilege!

The other objection to Friedman's argument is that 'real change', world-shattering change, does indeed happen without a crisis. Writing in the very same year Eric Hobsbawm quoted the car industry as an example:

"It is not the demand for motor-cars existing in the 1890s which created an industry of the modern size, but the capacity to produce cheap cars which produced the modern mass demand for them" (Age of Revolution 1962)

We have already mentioned the mobile phone:

The first telephone call using a portable handheld device was made in 1973 by Marty Cooper of Motorola - he called his great rivals at Bell Laboratories. In a recent interview he admitted:

"We had no idea that in as little as 35 years more than half the people on Earth would have cellular telephones, and they give the phones away to people for nothing."

"In fact we had a joke that said 'in the future, when you were born you would be assigned a telephone number and if you didn't answer the phone, you were dead'"

Most of us have more than one number; we have PINs and passwords for every username of our multiple identities. We have gone well beyond that joke. And therein is the secret of the mobile phone: it consistently gives us more than we ask for, more than we need or indeed want – games, cameras, music, video – and the ability to send them to each other. It creates and exceeds demand and becomes a 'necessity'.

The irony is that the mobile phone (for which there was no necessity) allows access to the Internet (for which there was also no necessity) and the resulting connectivity brings unprecedented possibilities to the very real challenges we described at the start of the book.

The point is that these truly game-changing innovations have not been driven by a pre-existing demand, a perceived necessity: they were in no way born of crisis, although they usually will cause a crisis for the status quo. Neither have they been driven by some far-sighted genius, whatever they might tell us now.

But that's not to say they came about by accident – they came about because they could: because someone saw a chance to satisfy a market that no-one else had seen in a way that no-one else had thought of. In short, someone had recognised an **opportunity**.

POSTSCRIPT:

Postcript

It is only recently that we have started to study exactly how we make decisions and solve problems. As our understanding increases so should our ability to make use of our greatest resource – our ingenuity.

Much of the material available for the study of innovation consists of stories of famous men and how they made their famous discoveries, but such a narrative history of connections between 'hero inventors' although attractive, is deeply flawed: we are only able to take into account those inventors and inventions which we know about.

We cannot tell who invented the loom or who first domesticated corn.

We know nothing about the 'genius' who invented the wheel and so are forced to leave the greatest invention of mankind out of our studies.

We are left with a preponderance of 'dead white men' to represent the ingenuity of the whole of mankind. And so the study of 'great men' and 'great inventions' is both limited and limiting. We may be better off studying creativity by looking at the context in which it occurs.

The problem solving process expounded above is a practical response to questions raised by the study of ingenuity. Where do ideas come from? Is innovation predictable or the result of chance? Can we teach and learn 'creativity'? What is 'genius'?

It's only fair to offer some conclusions: Innovations emerge from an array of old ideas and concepts, which we use as building blocks to construct new concepts - the wider the array, the greater the possibilities.

We can add to the variety of the array by turning our building blocks over to reveal qualities that we had not seen before. It is these 'sidelong glances' which seem to be most productive of novelty.

And so we should not be surprised that a similar array is likely to produce similar innovations, be it the development of agriculture or the invention of the motor car – in this regard innovation is the inevitable product of the 'zeitgeist'; there's 'something in the air'.

There is also a degree of predictability about the exploitation of successful innovations – it is to be expected that one discovery will lead to another.

'Chance' can be regarded as the sudden injection of fresh elements into an existing array, causing an expansion of the available possibilities in a manner that was not foreseen.

So not all innovation is inevitable and not all innovation is driven by necessity. But for the rest we do not have to rely on providence: creative problem solving actively seeks out good fortune rather than waiting for it to happen – our process engineers the circumstances in which serendipity is to be expected.

We have shown that creativity is an everyday faculty of humanity: it is as natural as breathing and just as we do not learn how to breathe, we do not learn to be creative – it is an ever-present element of our consciousness - what we call 'genius' is one end of a continuum. 'Genius' is a word which may be better used to describe a moment than a person, a moment of creativity which takes us by surprise through its sheer quality.

Just as singers and sportsmen sometimes have to re-learn their breathing techniques to improve their performance, we should be able to enhance our natural abilities with practice. Every one of us is capable of moments of 'genius' if, like the entrepreneur, we recognise them and take action.