HISTORY OF THE BRITS
CHAPTER 15

NUMERACY, THE SEVENTH PILLAR OF WISDOM

"*Mathematics is a human activity and is subject to all the foibles and frailties of humans. Any formal, logical account is pseudo-mathematics, a fiction , even a legend, despite the element of reason."* Morris Kline, "Mathematics, the Loss of Certainty" [Note 5]

1 INTRODUCTION

If there is one truth we have learned over the past 5,000 years it is that few matters are absolutely certain, absolutely right or absolutely wrong; Voltaire put it : "Doubt is uncomfortable; Certainty is absurd". As we have matured so we have come to decide "On the balance of probabilities", to advance towards the truth by a series of "successive approximations". As we argued in Chapter 5 Progress seems to require six qualities: Curiosity, Honesty, Adaptability, Tolerance, Literacy and Democracy. But there is one more and that is Numeracy. The weighing of Evidence in the scales is an essentially quantitative process – which is more and which is less. While it doesn't have to be done with actual numbers it is nevertheless a weighing process – to determine on which side of the argument the weight of evidence comes down.

Literacy has brought with it the ability to compound many more clues together. Numeracy enables us to weigh in with two new *kinds* of clues: numbers and measurements. Indeed some important arguments are of a purely quantitative nature (e.g. 'Civilization and Moon-power' Ch.2). Thus a language for describing and analysing purely numerical evidence has become essential to the modern thinker. Unfortunately many otherwise intelligent Brits find mathematics both unnatural and distasteful. They can only get away with it because so many of their fellow citizens

are likewise afflicted. Thus they have tolerated a succession of innumerate prime-ministers where they would never have put up with an illiterate one. Numeracy, unlike flower-arrangement, is no longer an optional accomplishment; sometimes it is the only way to discern the truth.

Fortunately innumeracy is not a congenital deformity – it is invariably the result of a misunderstanding by the teaching profession that goes back over 2000 years. The Brits, if they wanted to, could easily put that right.

2 NUMERACY AND BRITISH HISTORY

Mathematics is not a national language but as this is a book about the Brits we might as well select our illustrations from their history:

(A) In 1619 John Briggs published the first Table of **Logarithms**. As he wrote in a preface: *"Logarithms are numbers invented for the more easie working of questions in Arithmetike and Geometrie… By them all troublesome multiplications and divisions are avoided and performed only by addition instead of multiplication and subtraction instead of division. The curious and laborious extraction of roots are also performed with great ease……. In a word, all questions not only in Arithmetike and Geometrie but in Astronomie also are most plainly and easily answered."*

Briggs' tables (mooted a decade earlier by John Napier in Sciotland) revolutionised Man's capacity to make the complex calculations vital to navigators, engineers, bankers, astronomers, insurers, surveyors, actuaries (pensions), shipwrights, architects, builders, gunners, merchants, cartographers, statisticians, taxmen……. Logs led naturally to Slide-rules (William Oughtred 1624) which no scientist or engineer would be without until the 1970s. Werner von Braun who, more than anyone else, got us to the Moon in 1969, never used anything else. It is likely that Logarithms speeded up human progress by a century – possibly two.

(B) In 1686 Isaac Newton published his famous '*Principia Mathematica'*. In it he demonstrated that the complex motions of the heavenly bodies could be

explained by three simple Laws of Motion – combined with his Universal Law of Gravitation. The details need not concern us but the implication was startling – even if Newton did not recognise that himself. The heavens appeared to run like **a colossal clockwork machine**, utterly predictable from one century to the next. It followed that all the capricious gods of the ancients couldn't be meddling with it. Indeed there was no real need for a god in it at all. None of the priests and potentates could make a. mite of difference to it. What a colossal liberation that would come to seem. We were in to The Enlightenment.

(C) In 1707 Admiral Sir Cloudesly Shovell's fleet, returning home from Gibraltar, ran ashore on the Scilly Isles drowning 2000 prime seamen including the admiral. With no reliable means of finding their **Longitude** the navigators aboard imagined they were safely far to the West. In the tragedy's aftermath the Brits of course set up a committee – The Board of Longitude – empowered to offer a vast prize to the first who could come up with a practical and accurate (to within 30 miles) method for finding the Longitude of any vessel out at sea. The Board also had sums to support inventors with promising ideas. One such was a self-educated Yorkshire carpenter John Harrison who decided, at age 21, to build a marine chronometer so accurate and so reliable that it would win the prize.(The Latitude is easily found from measuring the altitude of the Pole Star)

Because the Earth rotates towards the East by 15 degrees every hour, finding the Longitude is all about measuring time. Local noon in Cardiff occurs 12 minutes and 43 seconds after it does at Greenwich, thus Cardiff is at a Longitude of 12 mins and 43 seconds West, which is, at Cardiff's Latitude, (51.5 degs. North), equivalent to 137.9 statute miles.

In Harrison's day there were thus two approaches to telling the time at sea—a marine chronometer of previously unimagined accuracy (a tenth of a second a day) or using the Moon as a clock-hand as it traverses its passage among the stars. But that 'Method of Lunars' would require tables of the Moon's sidereal trajectory to be

calculated years in advance – as it happens a fiendishly hard task. Many men set out to win the Prize but only two succeeded. In Yorkshire, in a 40-year technical tour-de-force that has never been equalled in history, Harrison produced a series of ever more precise chronometers which eventually (1761) accomplished the task of navigating HMS *Deptford* from Portsmouth to Jamaica with a positional accuracy of better than 2 miles! In Germany the surveyor Tobias Mayor produced a table of Lunar positions of equivalent accuracy, and both eventually shared the prize, deservedly so for the two methods were complementary. For a practical seaman the chronometer was far more convenient, but every so often it would need correcting – using Lunars.

Astronavigation would change the world and Britain's place in it. So equipped Captain Cook (1768 -71) was sent out to explore the Pacific (and secretly to find a new supply of giant trees that could provide superior masts for the Royal Navy's biggest battleships). He found and mapped New Zealand, Australia and NW Canada, and 'claimed' all three for Britain (and incidentally found those masts on Norfolk Island). But, far more important, astronavigation made ocean-voyaging so much safer and therefore cheaper, that the whole world could now trade for basic commodities like wheat and wool, not just for slaves and spices. The Admiralty took on the task of charting the Seven Seas and publishing them for all to use.

(D) In 1864 a Scots physicist James Clerk Maxwell, first composed the equations which describe the discoveries of the experimental electricians Hans Christian Oersted (1820) and Michael Faraday (1831). His discovery was eventually to prove far more momentous than 'the discovery of ' America. Why? First because his equations argued, to general astonishment, that **electromagnetic signals** should travel through Space at the speed of Light – indeed that Light itself was an electromagnetic wave. Second because they implied that there must be deep flaws in our understanding of Space and Time. After Maxwell the bulk of the modern world would be born – broadcasting, the radio-demagogues, television, code-breaking, computers, Relativity and smart-phones were all waiting in the wings of History. Maxwell's name is not as well known as other titans of Science such as Darwin and

Einstein – but it ought to be. James Clerk Maxwell has probably changed your life more than any other figure from history.

(E) While the British climate is almost ideal, its **weather** is highly unpredictable – or rather it was. Nowadays we know to the hour when it is going to be fair or foul and can alter our plans accordingly. But how? Because a Quaker polymath from Newcastle Lewis Fry Richardson realised one could write down all the Partial Differential Equations describing the atmosphere, and then solve them numerically, that is to say by slogging them out with slide-rule or computer. Since there were no electronic computers in his day (1920) Richardson envisaged a huge auditorium filled with clerks with slide-rules. Each was to be responsible for a smallish cube of the atmosphere but would keep in touch with the clerks responsible for the 6 cubes abutting his or her own. Whilst serving as an ambulance driver in WW1 he actually carried out a trial calculation to prove its feasibility. After electronic computers became available in the late 1940s they were harnessed to the task, with ever increasing success.

(F) Thus far in this section I have been 'triumphal'. Now I will describe just one of the dire consequences of the innumerate British elite. In 1996 the 140,000 ton tanker *Sea Empress* ran onto the rocks at the entrance of Milford Haven in West Wales. Despite the best efforts of all the Queens tugs and all the Queen's men she couldn't be towed off before most of her cargo of crude oil had breached from her shattered hull to despoil beaches and murder sea and bird life for 50 miles around. It was an ecological catastrophe. Nobody wanted to take responsibility. Neither the ship nor its cargo were properly insured (they never are – it's too risky for insurance companies). The Port Authorities attempted to prosecute their own pilot. The subsequent government Inquiry was a white-wash which concluded that because the vessel's sea-worthiness certificate was up to date it was in no way to blame.[Look for OIL TANKERS in HOB&&&]

But it was. Entirely so! It was far too big and clumsy to be allowed anywhere near the rocky tidal coast of Europe, and yet it was only half the tonnage of a true

'VLCC' [Very Large Crude Carrier]. Such monsters are bigger than the Empire State skyscraper, weigh 3 times as much, take 20 kilometres to stop and 15 minutes to turn, have no effective brakes or anchors, cannot be controlled by tugs in any wind, and sometimes have to be crabbed at 45 degrees to their direction of travel to squeeze them into port against the tide. It's crazy!!!!!! One slight error of judgement by the crew, the pilot or a tug captain and they're on the rocks, with catastrophic effects for Man and for Nature (and yet they don 't save a penny on the price of a litre of fuel). Yes it is crazy!!!! When the *Amoco Cadiz* (1978) lost its steering engine in the Bay of Biscay even the most powerful tug in Europe couldn't turn its head a few degrees against the wind, and so prevent it crashing into the coast of Brittany with the spillage of 275,000 tons of crude oil. I got involved in the subsequent *Sea Empress* Inquiry but found it all but impossible to persuade educated but innumerate people that if you scale something up too far it can lead to fatal consequences. A VLCC, because of its sheer size, has no brakes, cannot turn out of danger, should never be allowed to carry oil, should always be fully insured, shouldn't be registered in a banana republic (as they all are), shouldn't be allowed anywhere near a rocky coast, indeed shouldn't be allowed on the high seas at all. But they are. The next *Sea Empress* disaster, the next *Amoco Cadiz* will happen any year now. It's simple mathematics, very simple. But our rulers simply can't do it, and what is worse, refuse to believe those who can. [Note 1]

When you scale any design up you usually change its properties in fundamental ways. Big trees have to be thicker in proportion than little trees – look around you. Men taller than 7 feet would be bed-ridden with crippled knees, ruptured discs, chronic constipation, shortness of breath and kidney failure. Turkeys cannot take off. Take a glass of tepid water and scale it up by a million. What would you have? A star like the Sun. **Scaling laws** are so ubiquitous that any adult ignorant of them is an ox blundering about in a minefield. We saw in Ch. 9 that men have had to fight throughout history just because of such a Scaling Law – 'the Square-Linear'. It

is no exaggeration to say that any innumerate society equipped with VLCCs, Atom bombs , container ships and Free Trade will do for itself sooner or later. [Note 2)]

3 THE REWARDS OF NUMERACY

are as various and subtle as those of Literacy. Here are some:

Numeracy:

(a) Encourages us to grow up philosophically and away from the childish need to brand arguments as either "Absolutely Right" or "Absolutely Wrong" towards "Which is stronger and which is weaker" .Thus it encourages a measured (civilized) approach to both thinking and discourse.

(b) Is the face of Weighing and Balancing, the Common Sense method of reaching wise decisions.

(c) Introduces new categories of evidence into Common Sense Thought – Counting and Measuring.

(d) Constantly reminds us of the deep Scaling Laws which can dominate both social and physical worlds.

(e) Will be essential if we are to confront and overcome the environmental problems we have brought upon ourselves largely through ignoring numbers. For instance 'How many people can a territory support sustainably? How many fish can we harvest from the sea? How much Carbon Dioxide can we vent safely into the sky? And how much will the sea level rise in consequence?'

(f) Enables us to break into new and unsuspected worlds, like Maxwell with his electromagnetic waves.

(g) Is the magic carpet which can transport the human mind to regions.

where no other vehicle can – the centre of the Earth for instance (seismology), or the centre of the Sun where all our energy arises.

(h) Is essential to help us build and refine new tools, from bridges to airliners. Thus Heaviside's simplified version of Maxwell (1890) speeded up

telegraphy by a thousand times while Tsilkovsky's mathematical analysis of the rocket (1903) foreshadowed Space travel.

(i) Is mandatory for any rational discussion of immigration and population. It is far more about numbers than principles.(Ch. 9,16, 19)

(j) Expands and enlightens both the possibilities and limitations of commerce. Without Discounted Cash Flow Analysis we cannot make wise long-term investment decisions; without algebra estimate the Sunken Costs of Free Trade; without Calculus sense the peril of an arms-race (Ch. 4)

(k) Helps us to winnow significant information out of the vast streams of data recorded nowadays.

(l) And, not least, it should lend us the self-confidence to challenge all those 'experts' who seek to overawe us with their imagined numerical tech-wizardry. We've already outed Half Baked Economists [Ch.14] but the world is crawling with other simpletons and charlatans who would like to persuade us that they know better than we do – but who very often are deluding themselves – before deceiving us.

It is practically impossible for an innumerate person to become wise.

4 BUT WHAT IS NUMERACY?

Rather than arbitrarily writing down a syllabus of what the properly numerate adult ought to know I think it better to sift back through our history book and identify episodes that depended crucially on numerical arguments. For instance:

- The Square-Linear law of fighting (Ch.9).
- The ideal climate and the SLOT (Ch 1).
- Moon-power and civilization (Ch 2).
- Leverage and banking disasters (Ch. 13).
- The instability of Arms Races (Ch 4).

- Critical battles in WW2 (Ch.10)
- Common Sense and Odds (Ch 5).
- Oil-tanker disasters (Ch 15).
- Discounted Cash Flow Analysis (Ch.25)

And so on; readers can make their own selection. Then, from that selection, a numerate person could list the specific numerical skills we would all need to know. Without going into detail I conclude that:

(i) Numeracy must comprise more than just Pure Mathematics; it must include some fundamental scientific concepts including:

- The Laws of Motion
- Heat and Energy
- Dimensions and Units.[Note 4]
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These matters fall under what is nowadays called ‘STEM’ (Science, Technology, Engineering & Maths)

(ii) Mathematically it must go at least as far as Ordinary Differential Equations and their solutions in simple cases. This means a fair amount of Calculus.

(iii) Since Common Sense Thinking involves gambling one needs familiarity with Odds, Probabilities, Permutations and Combinations.

(iv) Given that so many problems which cannot be solved exactly can nevertheless be solved numerically using electronic means, I would include some limited experience of approximations, algorithms and computer-coding.

Whilst a Numeracy Certificate should be the ambition of every school leaver, facilities for adults to pick Numeracy up should be paramount. We must all become numerate; for ourselves, for our society, and for our planet. And we could.

5 HOW TO BECOME NUMERATE

Many Brits are proud to own that they are no good at maths – as if it were a nerdy, rather grubby activity best left to inferiors [In its ignorance my *Economist* newspaper sometimes refers to numerates as 'pointy- headed wonks'] It obviously has nothing to do with their level of intelligence; even Churchill was innumerate – but that nearly cost us WW2. To make up for his deficiency Churchill formed the closest of bonds with Frederick Lindemann who thereafter became Lord Cherwell, "the most powerful scientist in history" [1]. Lindemann's trick was to perform lightning-fast calculations in his head – which impressed Churchill and the other innumerates around the Cabinet table. The trouble was that many of those calculations were wildly wrong – and nearly cost us WW2. Lindemann's scientific contemporaries knew they were wrong but because Lindemann was Professor of Physics at Oxford no less, and such an intimate of the PM, they weren't attended to. Lindemann almost scuppered the development of radar in favour of dangling bombs on wires in front of enemy bombers (The Tizard Committee had to dissolve itself to get rid of him). (Note 3)

The reason so many Brits are innumerate is because of a basic misunderstanding that arose amongst the Ancient Greeks 2000 years ago. Greek geometers were obsessed with 'Proofs', watertight deductive arguments as to why certain propositions, such as Pythagoras' Theorem, were true. They were so delighted with their discovery of this power of Deduction that ever since Maths teachers have taught their pupils deductively, even though Deduction is an unnatural mode of thought for humans, even for creative mathematicians. Instead we use Common Sense Thinking, or *Induction*. Maths teachers have mistaken the grocery bill for the groceries, legalism for morality (See quote from Kline heading this chapter0. Thus they have put off 80 generations of children who naturally rebelled. What a tragedy – almost on the same scale as Christianity [Note 5].

Once we recognise that misunderstanding it shouldn't be hard to put it right and help nearly everybody to become properly numerate. I know because I have

taught higher mathematics deductively in a university Maths department –where it was almost a complete failure, and the *same mathematics* inductively in a Physics department, where it was almost a complete success. Once they could use their natural inductive methods of thinking students found they could get their heads round the toughest mathematical ideas (e.g. Vector Calculus and Maxwell's Equations – see above) because the reward (revelation) was more than worth the effort – far more. It was a pleasure to watch their faces light up, their young bodies literally grow in stature [By contrast the Mathematics students shrank and half of them failed to get Honours degrees. Ironically many of those 'failures' would go on to teach mathematics in schools, so handing on failure and innumeracy from generation to generation.]

Alas one is not going to change the mathematics profession, or its teaching methods, overnight. But there has to be a way. We cannot afford to remain innumerate in an ever complexifying world. Fortunately Mathematics is peculiarly well suited to on-line teaching. So I would propose:

(a) Issuing a national syllabus for what every properly numerate adult should be expected to know. (Note 5)

(b) Holding exams for a nationally recognized Diploma in Numeracy.

(c) Rewarding every individual (of whatever age) who obtains the Diploma an immediate cash award of *at least* £5,000, better £15,000.

(d) Reserving many plum jobs in government employment, and elsewhere, for those so qualified.

If you suppose that would be impractical recall that at present:

(i) British children attend school for a dozen years at

a cost of about £5,000 per annum – and yet mostly emerge innumerate.

(ii) British university students pay about £30,000 each just in tuition fees and yet mostly still emerge innumerate.

So the average, and innumerate Brit, is still costing £75,000 to educate (half now go to university). If only 10 % are numerate now (optimistic) each one of those is costing society approaching £750,000. That of course is an exaggeration because there are other values to education – Literacy for instance. But if numeracy is something like one third of the aim then we are wasting over £200,000 per citizen at present. Thus even a cash reward of £15,000 per Diploma in Numeracy would be an amazing bargain.

6. BUT WHAT ABOUT NATIVE ABILITY?

The other obstacle to progress is the lazy assumption that only a few have a native faculty for mathematics whilst the rest are born dumb. In fact, given the right stimulus, all of us can numerise loud and clear. I've seen it as a teacher, have experienced a mathematical epiphany myself. As a child I suffered from two phobias: of Mathematics and Spiders – the last as the result of a horrific experience when I was 4. So, like many with a phobia, I read everything I could find about spiders, and poked under the bed at night before getting in, in case there was a monster there drooling in the shades. But then, at age 14 I came across an alleged mathematical proof that spiders could never grow beyond a modest size (it was a Scaling Law). Unfortunately I was hopeless at Mathematics (114^{th} out of 120 in my year at school). But in the circumstances it did seem worth trying to understand the spider-proof. After a two-day struggle the penny dropped. Nightmare spiders vanished from my life forever and within weeks I was easily top of my entire year at Maths. Mathematics, you see, is an inspirational subject like music or poetry. You just need the right stimulus "… to hear the horns of elfland faintly play".

7 IN CONCLUSION

From the battles of Ancient Rome to modern banking disasters, from astronavigation to philosophy, we have seen what a powerful, if often unseen role, Numeracy, and its opposite, have played in British history.

Numeracy is the Seventh Pillar of Progress – or Wisdom one might say. [A useful mnemonic to recall them all quickly is 'CHANTL(i)D' standing for : Curiosity, Honesty, Adaptability, Numeracy, Tolerance, L(iteracy), and Democracy].

At a certain level (the 3 R's) Brits are aware of the importance of Numeracy. But, through a 2,000-year-old misunderstanding, they have allowed the maths-teaching profession to seriously muck up their children's education. If they want to they could easily put things right. To do so might cost £100 million a year. But that is a mere trifle compared to some large infrastructure projects which could never hope to electrify a whole society to anything like the same extent. For instance:

HS2 Rail	~	£88 Billion (2019
Cross Rail B.	~	15.4 Billion (2019)
Third runway Heathrow	~	£15 Billion (2019)
Enumerating an entire generation (30 years).	~	£3 Billion
Enumerating whole nation.	~	£6 Billion

NOTES

NOTE 1 You can see just how foolish allowing colossal oil tankers is by following the inquiry into the *Sea Empress* disaster. Once again the best way to analyse things is to look into critical timescales. To be safe any pilot, or indeed any safe driver, must have plenty of time to steer out of trouble. Driving too fast, or slowing down one's reactions with drink, can be fatal. Obviously. But the maritime authorities in Britain will not concede that. A VLCC pilot is expected to make every

decision perfectly, every time. As I say it's madness. But the authorities can't see that. They're innumerate! Follow the story at https://tinyurl.com/y8a7aoqr.

NOTE 2 The Sun has been shining unabated for about five thousand million years! That seems miraculous until you realize, *gram for gram*, it is giving off no more heat than a tepid glass of water. How come then that it looks like a fiery furnace, not like a glass of tepid water? It's a Scaling Law! They're everywhere. They control every aspect of our lives. Do you understand them? Once you do they make life so much more interesting![See the book *Scaling* by Geoffrey West on Kindle]

NOTE 3 It was CP Snow[2], the famous novelist of science, who called Lindemann "The most powerful scientist who ever lived " and he was right. The 'Prof" as he liked to be called amongst his country-house friends, was both hero and villain. In WW1 he worked out why so many aircraft went into the death spins which killed one in 5 trainee plots. Then *theoretically only*, he worked out how to pull out safely. Then he had himself taught to fly. Then, without a parachute, he put his plane into a spin and lived to tell the tale; the first pilot ever to deliberately so do and survive. He was incredibly brave and all pilots have been grateful to him ever since; I know I am. Churchill greatly admired courage so that is why he made the Prof his most trusted ally and closest friend between the wars and during WW2. But Lindemann was also a dangerous man to associate with. He turned on almost all his family, his friends and his former associates like Tizard, who had originally got him his chair at Oxford. He wasn't much of a scientist but loathed anyone who disagreed with him. As such he did more harm to the British war effort than any other German bar Hitler; a fascinating but repellent character. You can read about him in *"Prof"* by Adrian Fort.

NOTE 4 UNITS. Scientists and Engineers continually make ‘back-of-the-envelop’ (BOE) calculations to see if some idea is feasible or not. They can be extremely crude, involving little more than the dimensions and units of the phenomenon concerned. Only if the crude calculation looks promising need one consider the idea any further. Thus such calculations are a first filter for separating good ideas from bad, surely something we *all* need. Consider a dramatic example`; the Industrial `Revolution worked only because a small amount of heat can generate a vast amount of mechanical energy. If you know your units (calories and ergs here) a BOE calculation reveals that the energy required to heat some water by only one degree Centigrade could instead lift it upwards half a kilometre! That is why very crude steam engines could pump out deep mines, power factories, drive railways and ships – but if you use the wrong units (which alas they teach at school and university) all this magic remains concealed. **Every wise person must be able to do back-of-the-envelope calculations on a daily basis.**

NOTE 5. Deduction plays an important role in Mathematics, because that subject has to be *self-consistent*, which is what Deduction is all about. Even so it can be greatly exaggerated. Mathematicians understandably like to have ‘proofs’ that what they are saying is unequivocally true. Unfortunately many such proofs have turned out to be flawed when examined by subsequent generations – who know more mathematics. So wise *users* of Mathematics expect no more absolute certainty in Mathematics than they can expect in the other arguments they have to employ. In other words the uncertainty involved in not having a definitive proof is often a quite acceptable gamble. Once that is conceded the necessity to teach mathematics deductively, which is so unnatural and so unsuccessful, evaporates. There is an enlightening and very readable discussion of this whole situation in Morris Kline’s wonderful *“Mathematics, The Loss of Certainty*” 1986 OUP. In a link on our website I show how one very important mathematical result (All triangles contain two right-

angles) can be taught either deductively or inductively, and you can decide which is best for you.

GENERAL ADVICE : Always look at our website **mjdisney.org** inside HOB&&& for more. It’s always accumulating. Remember this is a LIVE BOOK

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