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THE ORIGINS OF BAR CHARTING

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Patrick Weaver FAICD, FCIOB, PMP.
Director, Mosaic Project Services Pty Ltd

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Additional information received since publication consolidated into the text.

See also: *A Brief History of Scheduling*
https://mosaicprojects.com.au/PDF_Papers/P042_History_of_Scheduling.pdf

The Origins of Modern Project Management
https://mosaicprojects.com.au/PDF_Papers/P050_Origins_of_Modern_PM.pdf

Mosaic's complete PM History resource is available from:
https://mosaicprojects.com.au/PMKI-ZSY.php

For more scheduling papers see Mosaic's Planning and Scheduling Home page:
https://mosaicprojects.com.au/PMKI-SCH.php

Mosaic Project Services Pty Ltd
PO Box 5150
South Melbourne VIC 3205 Australia
Tel: +613 9696 8684
Email: Info@mosaicprojects.com.au
Web: www.mosaicprojects.com.au

Introduction

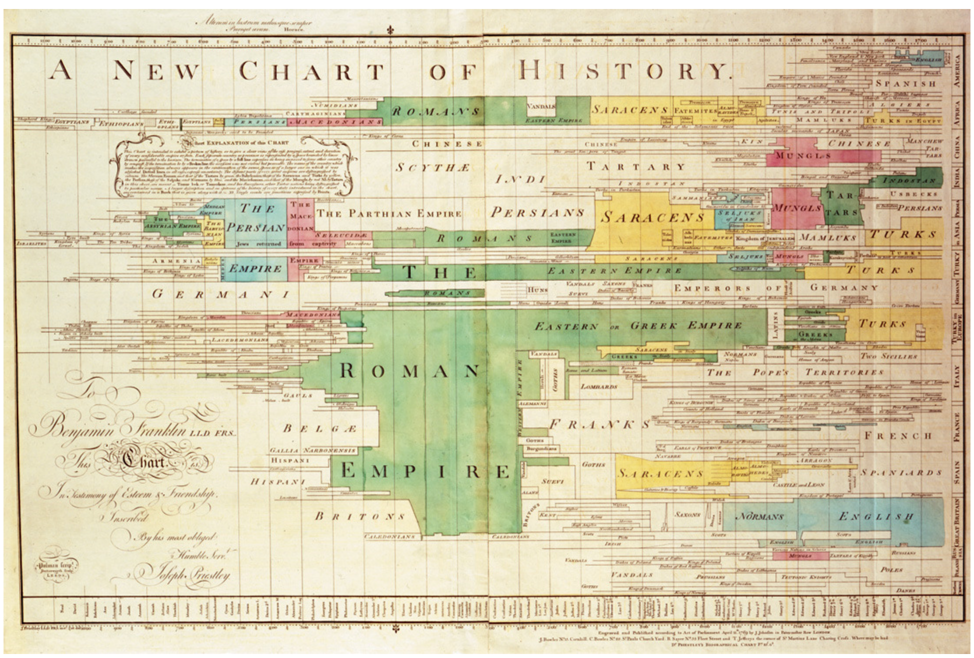
In a series of previous papers I have looked at:

- The origins of modern project management[1];
- The development of scheduling[2] which traces the development of scheduling from barcharts in the mid-1800s through to modern tools and practice;
- And debunked the myth that Henry L. Gantt developed bar charting or had anything to do with the evolution of project management or bar charts[3].

Whilst developing these papers, focused on 'modern project management', one of my untested observations was that the charts used by Priestly and the graphs used by Playfair in the 18th Century were advances on much older developments. They simply appeared to be too good to be original concepts. This paper looks at the origins of the concept used by both Priestly and Playfair as a starting point to develop their charts which in turn led to the development of the modern bar chart by the late 1800s[4].

Bar charts are in essence a stylised graph, where data in the form of a start and end point for a line (or bar) is plotted against an 'x' and a 'y' axis with the activities defined on the 'y' axis and time on the 'x' axis. These key concepts can be seen in each of the following charts:

A New Chart of History[5]: Joseph Priestley (England, 1733-1804). The rule of 'empires' are plotted against geographical location and time requiring mapping and graphing concepts:



1 ***The Origins of Modern Project Management***: http://www.mosaicprojects.com.au/PDF_Papers/P050_Origins_of_Modern_PM.pdf

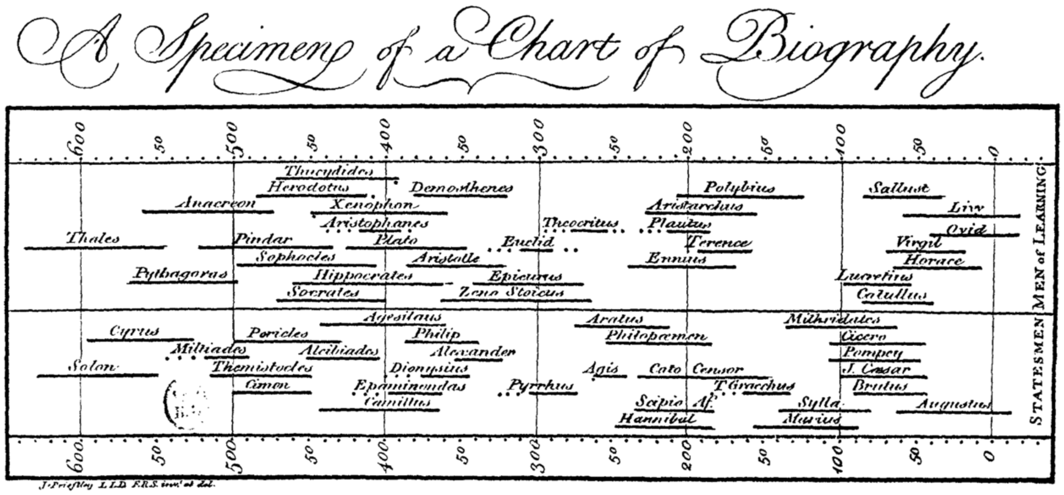
2 ***A Brief History of Scheduling***: https://mosaicprojects.com.au/PDF_Papers/P042_History_of_Scheduling.pdf

3 ***Henry L. Gantt - A Retrospective view of his work***: https://mosaicprojects.com.au/PDF_Papers/P158_Henry_L_Gantt.pdf

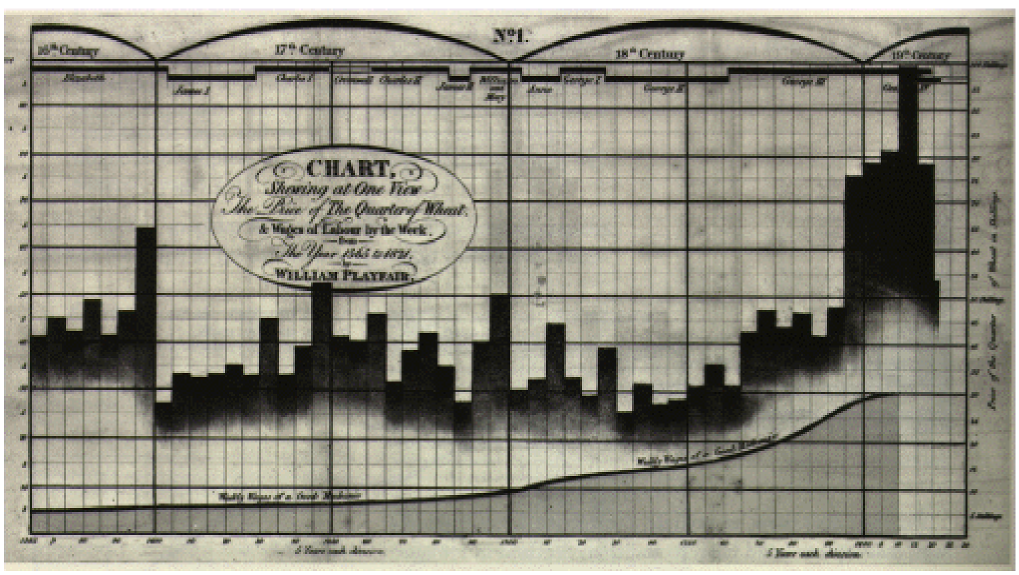
4 For more information on the charts developed by Joseph Priestley see: https://mosaicprojects.com.au/PMKI-ZSY-020.php#Barchart

5 For more on *'A New Chart of History'* see: http://en.wikipedia.org/wiki/A_New_Chart_of_History.

A Chart of Biography[6]: Joseph Priestley (England, 1733-1804). Some 2000 famous lifetimes plotted on a time scaled chart:



Commercial and Political Atlas[7]: William Playfair (1759-1823). Contains a range of statistical charts including the line, bar (histogram), and pie charts combining data with graphing techniques.



This marriage of numbers and geometry to create a graph was first achieved by Nicole d'Oresme in the middle of the 14th century but the starting point is even earlier! The Ancient Greeks built on the practical application of numbers and geometry used by the Babylonian and Egyptian civilisations, to develop all of the concepts used by Nicole d'Oresme to create a graph; so where does the journey towards modern bar charts start?

[6] For more on *'A Chart of Biography'* see: http://en.wikipedia.org/wiki/A_Chart_of_Biography.

[7] For more on the work of William Playfair see: http://en.wikipedia.org/wiki/William_Playfair

The Origins of Numbers and Geometry[8]

The first moves towards the abstract concept of numbers, seems to have occurred between 6000BC and 3500BC in the Nile valley. By around 3500BC, the Egyptians had developed writing and invented the second of the *'only two things in life that are certain'* taxes – to be precise, land tax. Land taxes required the calculation of areas and the understanding of shapes, the basis of geometry. By 2580BC these skills facilitated the design and construction of the Great Pyramid which required very sophisticated 'applied geometry'. The Egyptian's mathematics were equally effective, but convoluted.

The civilisations that developed in the 'fertile crescent' between the Tigress and Euphrates rivers from around 4000BC were forcibly merged into the Babylonian civilisation between 2000BC and 1700BC. Babylonian engineers were quite capable of calculating the volume of earth to be excavated in a canal of a given length, knowing its cross section is trapezoidal, knowing the volume of earth a digger can excavate in a day and calculating the number of man-days needed for the job (and presumably then being able to assess the duration based on the size of the crew, or the crews needed to achieve a given duration). Written records on clay tablets also suggest they understood what we call Pythagoras' theorem (in a right triangle, the square of the hypotenuse is equal to the squares of the other two sides – a relationship the Egyptians also used).

Thanks to trading relationships, and then Alexander the Great conquering these civilisations, the Ancient Greeks accessed and used this knowledge to develop geometry and mathematics to an advanced level. The 'golden age' of Greece began around 2500 years ago, when a Greek merchant-turned-philosopher named Thales moved mathematics from the practical calculation of taxes and volumes into the abstract.

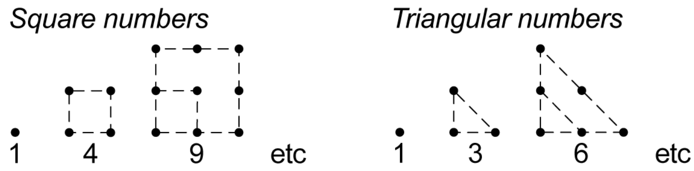
These were remarkable time; Buddha was born around 560BC, Confucius was born in 551BC and was part of the *Hundred Schools of Thought*[9] that flourished in ancient China from the 6th century to 221 BC, and Thales of Miletus was born around 640BC. In a quest for knowledge he spent significant amounts of time in Babylon and Egypt and is credited with starting the move towards theory and proof by deriving geometric principles from practical applications. He was the first to prove geometric theorems of the type Euclid would compile in his *Elements* centuries later. He kept the Egyptian name for these calculations 'earth measurements' which in Greek becomes *geometry*.

Much of the knowledge rediscovered in the European Renaissance some 1000 years later was defined and documented by the Ancient Greeks in the millennium following Thales:

- Thales determined nature follows regular laws and mathematical conclusions about the world should be verified by rules.
- Anaximander. A student of Thales developed the concept of evolution and created the first 'great world map' around 550BC.
- The young Pythagoras met Thales when he was an old man and carried on his work consolidating mathematical abstraction. To the Egyptians a line was something such as the edge of a field which was different to the side of a pyramid, Pythagoras realised that a line could be many things including the flight of a bird, and that the properties of a line can be transferred between these different occurrences. The Pythagoreans also discovered:
  - Harmonic progression which phrases the physical world in mathematical terms;
  - Square and triangular numbers (the term 'square' is derived from the pattern of pebbles created by these studies);

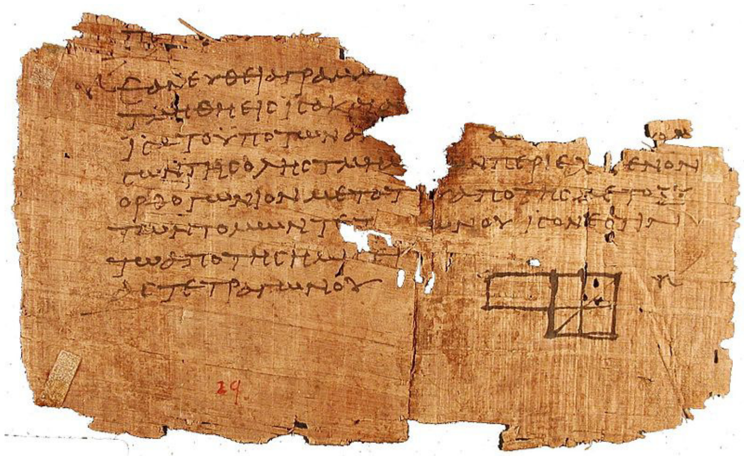
[8] The source of much of the material in the section is*: Euclid's Window : The Story of Geometry from Parallel Lines to Hyperspace*, by Leonard Mlodinow

[9] Within the 'Hundred Schools', the philosophy of the *School of Logicians* focused on definition and logic and has parallels with that of the Ancient Greeks.



- o Many of the properties of triangles;
- o Irrational numbers[10] (but these were kept secret[11]);
- o And the idea the world was a sphere.

- Euclid consolidated much of this learning into his ‘Elements’ around 300BC. Focusing on organising and systemising the knowledge.



Oxyrhynchus papyrus showing fragment of Euclid's Elements

- Ptolemy II built the great library at Alexander in the 3rd century BC
- Eratosthenes of Cyrene calculated the circumference of the earth in 212BC to an accuracy of 4% using geometry.
- Aristarchus of Samos then calculated a reasonable approximation of the size of the moon and its distance from earth.
- Archimedes discovered the principles of the lever, buoyancy and a version of calculus.
- Aristotle proposed the idea of dividing the world into horizontal climate zones and Hipparchus expanded on this concept to spacing the lines at equal intervals and adding North-South lines at right angles. These lines became known as ‘latitude’ and ‘longitude’.
- And Ptolemy’s *Geographia* was the first serious attempt at map making dealing with the challenge of representing a spherical surface on a flat page. To locate positions he employed latitude and longitude as coordinates. What’s important to remember is that at a conceptual level, a map is simply another form of graph plotting data against an ‘x’ and a ‘y’ axis.

[10] An irrational number is any real number that cannot be expressed as a ratio of integers. Irrational numbers cannot be represented as terminating or repeating decimals. Two common examples are the square root of two and ratio π of a circle's circumference to its diameter.

[11] Breaking the secret could be fatal: The sect of the Pythagoreans was based on the perfection of numbers and geometry which is rather challenged if you cannot define the length of the diagonal of a square…… particularly when you preach that ‘numbers are everything’. To solve the conundrum the Pythagoreans called such lengths *‘alogon’* - the word has two meanings, ‘not a ratio’ and ‘not to be spoken’. According to legend, when one of his followers, Hippasus broke the oath of silence he was assassinated which is certainly taking an interests in numbers to an extreme!

- The two major 'gaps' in Greek reasoning were the separation of mathematics and geometry, they believed these two concepts were independent (which affects our story); and the assumption the planets and sun revolve around the earth. The planets movements were accurately recorded and predicted in Ptolemy's Almagest and replicated mechanically in the *Antikythera mechanism*[12], but the much simpler option of recognising the sun as the centre of rotation was missed.

The Romans appreciated the usefulness of many aspects of Greek mathematics and geometry but as an aid to martial conquest. They borrowed heavily from the Greek to write Latin version of the 'useful ideas' but without much in the way of proofs.

The decline of the Roman Empire almost obliterated the knowledge developed in the Greek 'golden age', probably the most significant single act of destruction being the murder of Hypatia, the last of the great Greek scholars to study at the library in Alexander and the burning of the library and its 200,000 or more scrolls by a Christian mob in 415AD. The fall of the Roman Empire in 476 AD completed the destruction.

Fortunately for Europe, much of the key knowledge was retained by the Byzantium Empire and then the Islamic civilisations[13] for the next 1000 years during the European 'Dark Ages'. During this period, European scholarship was both nurtured and suppressed by the Church. Monasteries were the centre of learning but publishing ideas that challenged orthodoxy frequently had fatal consequences for the philosopher - repatriating ideas from the surviving Greek manuscripts into European thinking was a dangerous process! Useful concepts such as modern numbers (imported by Fibonacci in the beginning of the 13th century[14]) and basic Euclidian geometry were fine, but the conclusions that could be derived from them could become a serious 'health threat' for the scholar.

The marriage of numbers and geometry to create a graph was achieved by Nicole d'Oresme[15] (later bishop of Lisieux) in the middle of the 14th century and he used this new tool to analyse quantitative relationships. As an educated monk, Nicole d'Oresme[16] was aware of geometry,

12 To appreciate the sophistication of the *Antikythera mechanism*, see: http://en.wikipedia.org/wiki/Antikythera_mechanism

13 Scholars during the Islamic 'golden age' actively sought books and knowledge. The Islamic Caliphate stretched from India in the East to Spain in the West and was connected to China through the 'silk road'. Most of the knowledge imported to Europe during the renascence together with philosophies such as 'scientific enquiry' was acquired, preserved and advanced by the Islamic centres of learning (Universities) during this period of open learning and enquiry by both Muslim and non-Muslim scholars.

14 For more on Fibonacci, see: https://mosaicprojects.com.au/Mag_Articles/P008_Are_Numbers_Real.pdf

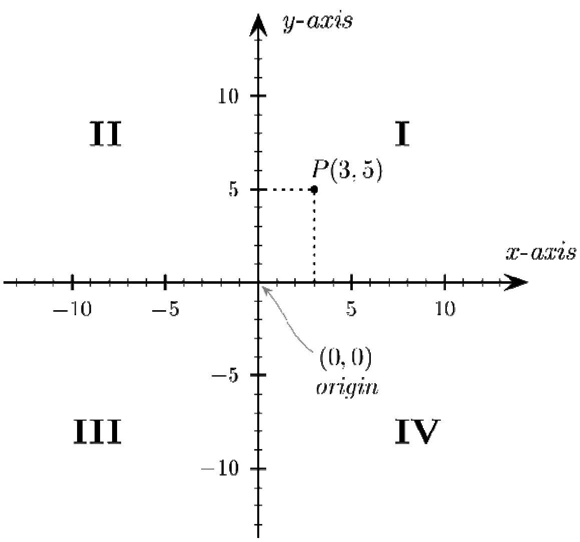
15 This image is from Nicole d'Oresme's book *Livre du ciel et du monde*, 1377, showing the heavenly spheres. He concluded that that if the Earth were rotating around its axis, rather than the celestial spheres, all the of the movements that we see in the heavens, that are computed by the astronomers, would appear exactly the same as if the spheres were rotating around the Earth. He also noted that it would be more economical for the small Earth to rotate on its axis than the immense sphere of the stars. To avoid problems he concluded that none of these arguments were conclusive and *"everyone maintains, and I think myself, that the heavens do move and not the Earth"*. Unlike Galileo and many others d'Oresme avoided religious sanction.

16 For more on Nicole d'Oresme, see: http://en.wikipedia.org/wiki/Nicole_Oresme

a useful underpinning for his graphs, but chose to ignore problems such as irrational numbers as an inconvenient concept in a 'perfect world'. His most important contributions to mathematics are contained in *Tractatus de configurationibus qualitatum et motuum*.

To quote from Wikipedia: "In observing a quality, or accidental form, such as heat, he distinguished the *intensio* (the degree of heat at each point) and the *extensio* (as the length of the heated rod). These two terms were often replaced by *latitudo* and *longitude* (ie, the Greek *latitude* and *longitude*). For the sake of clarity, Oresme conceived the idea of visualizing these concepts by plane figures, approaching what we would now call rectangular co-ordinates. The intensity of the quality was represented by a length or *latitudo* proportional to the intensity erected perpendicular to the base at a given point on the base line, which represents the *longitudo*. Oresme proposed that the geometrical form of such a figure could be regarded as corresponding to a characteristic of the quality itself." In other words he graphed the data!

Oresme extended this doctrine to figures of three dimensions, and considered this analysis applicable to many different qualities including the analysis of local motion where the *latitudo* or intensity represented the speed, the *longitudo* represented the time, and the area of the figure represented the distance travelled.



René Descartes advanced the ideas of Nicole d'Oresme developing Cartesian geometry[17] which uses algebra to describe geometry and is the underpinnings of modern calculus[18], his 'mathematical laziness' may be 'notorious' but can also be seen as the rigorous application of 14th century Franciscan, William of Occam's razor – 'Occam's razor[19]' is a scientific and mathematical aesthetic that states *"one should strive to create theories based on as few ad hoc assumptions as possible"*.

A Cartesian coordinate system specifies each point uniquely in a plane by a pair of numerical coordinates, which are the distances from the point to two fixed perpendicular directed lines. The idea of this system was developed in 1637 in writings by French mathematician and philosopher René Descartes (who used the name *Cartesius* in Latin), and independently by Pierre de Fermat. Both authors used a single axis in their treatments and have a variable length measured in reference to this axis. The concept of using a pair of axes was introduced later, after Descartes' *La Géométrie* was translated into Latin in 1649 by Frans van Schooten and his students.

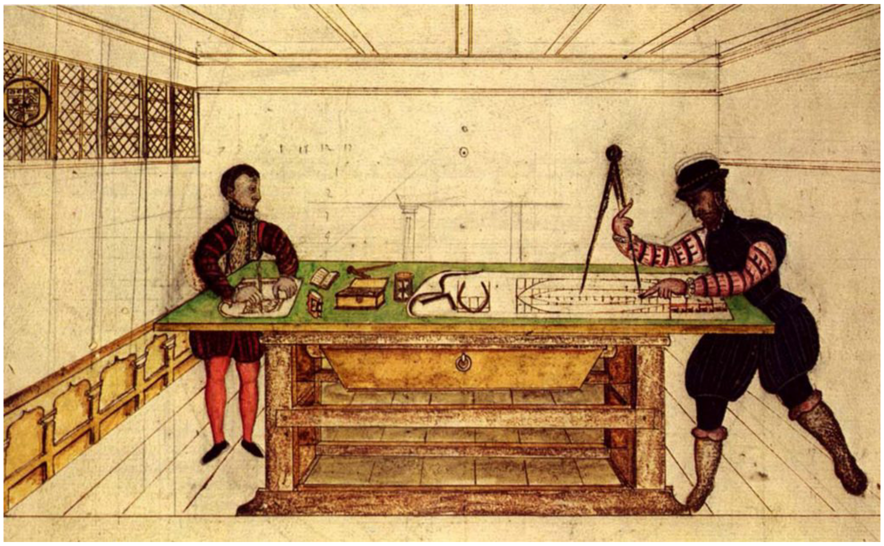
Another underpinning of modern barcharts is the use of accurate diagrams drawn on paper to represent complex concepts and shapes predates Descartes by some 100 years. Mathew Baker (c.1530-1613) was a royal master shipwright under Queen Elizabeth 1st, and an important figure

[17] For more on Cartesian coordinates see: http://en.wikipedia.org/wiki/Cartesian_coordinate_system

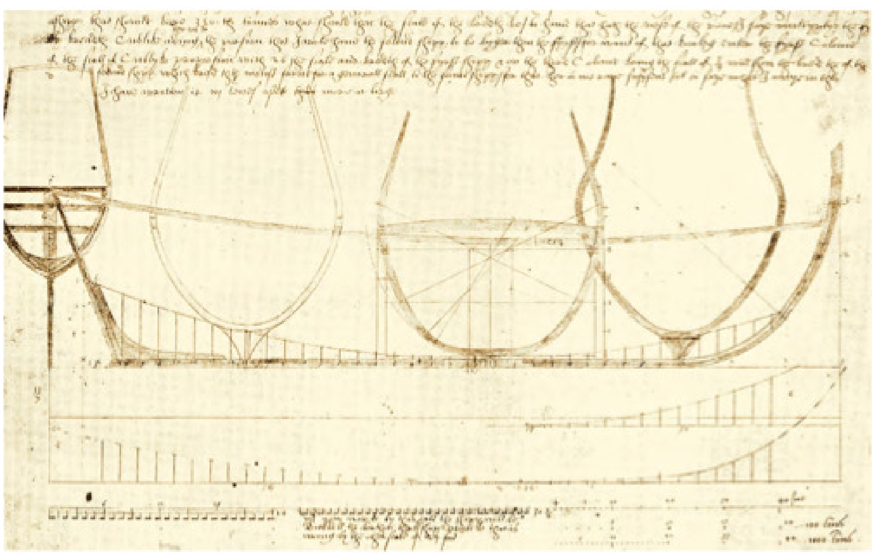
[18] Gerardus Mercator developed his map projection empirically in 1569. Descartes was aware of Mercator's maps but how much influence these had on his work is uncertain. For more on Mercator see: http://en.wikipedia.org/wiki/Mercator_projection

[19] For more on Occam's razor see: http://en.wikipedia.org/wiki/Occam's_razor

within the small but developing naval establishment. His manuscript known as *Fragments of Ancient English Shipwrightry*[20] is an early example of complex design being developed on paper.



By the 16th century an apparatus of simple though powerful rules and techniques had been developed for building large vessels. Ship design was memorised in proportional rules, and its complex curves generated and recorded by full-size wooden moulds or templates. Technically advanced shipwrights employed a sophisticated constructive geometry which used wood rather than paper and took place not in a design office but out in the shipyard itself.



With Baker, the very medium of design has been transformed. The master works with dividers on the plan and section of a ship, translating the complex geometry of a ship's shape into miniaturised form through the technique of scaled drawing and using Arabic numerals for calculation. His manuscript

[20] Mathew Baker's manuscript was christened *Fragments of Ancient English Shipwrightry* when it was acquired and preserved by Samuel Pepys. Pepys's choice of title was deliberate and appropriate. *Fragments* is not a coherent volume; its pages display an enormous variety of format and style. Some parts are finely executed, perhaps for a planned presentation volume, while other sections are no more than notebook pages.

pages became a means by which technique, control, teaching, administration and the navy could be juxtaposed and combined[21].

Compared to this level of complexity a standard bar chart, with time on one dimension, the activities on another, and the start and end points for the bar representing the duration defined by reference to both would seem to be based on this Cartesian coordinate system.

Summary

Whilst there is no way to be sure of the precise origins of modern bar charts, the Ancient Greek intellect certainly contained all of the underpinnings needed for their development including geometry, coordinates and the calculation of man-days of effort. These principles were then combined into graphs by Nicole d'Oresme and then into a *Cartesian coordinate system* by René Descartes[22].

As classical scholars during the enlightenment both Priestly and Playfair would have been schooled in the works of the Ancient Greeks and Descartes. The concept of using a spatial (coordinate) reference system underpins their work, with much of the data used by Priestly in his two charts coming directly from the Ancient Greek manuscripts.

From this basis, the link between the work of Priestly and Playfair and modern bar charts is obvious and discussed at length in ***A Brief History of Scheduling***[23]. All that is missing now is to trace the development and actual use of bar charts for the control of projects during the 19th century industrial revolution. Candidate projects include the construction of the Eifel Tower and Crystal Palace but so far I've been unable to find conclusive documentation describing how the workforces used on these projects were controlled and managed from a time perspective.

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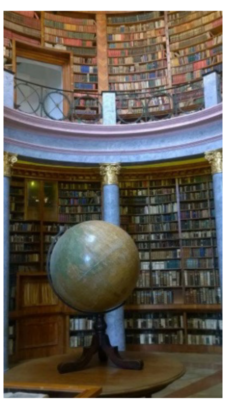

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21 For more on ***Mathew Baker*** see: http://www.mhs.ox.ac.uk/staff/saj/thesis/baker.htm

22 To see the events discussed in this paper in a comprehensive historical timeline download ***Project Management - A Historical Timeline***: https://mosaicprojects.com.au/PDF_Papers/P212_Historical_Timeline.pdf

23 See ***A Brief History of Scheduling***: https://mosaicprojects.com.au/PDF_Papers/P042_History_of_Scheduling.pdf