Chapter 5

The transformation of scientific and geographical education in eighteenth century England

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Introduction

This chapter examines the expansion and reformulation of the sciences and geography as educational subjects in the long eighteenth century, between 1680-1830, in the context of Britain's development as a dominant global power. It explores how sciences such as astronomy, natural history and natural philosophy and geographical education projected views of the nation and the participation of its subjects. The focus is primarily upon England, although the scope of geographical affiliation, including ideas of 'nation', take in other parts of Britain. These developments were also closely connected with educational ideas and practices in Europe, the British colonies and North America. The chapter explores both formal, institutional instruction and professional training in the home, schools and academies, as well as more informal kinds of accomplishment (for example in the realm of female education) in the domestic sphere. It examines the significance of a variety of scientific and geographical skills from forming collections of objects for natural history, studies of the celestial and terrestrial globes and map-making to memorising. A central issue is the role of scientific and geographical education as an ordering framework, mediating the practical and genteel spheres of polite society, both expressing and managing the powers of a consciously imperial nation.

The chapter contributes to investigations of the cultural-historical spaces and networks of science and learning and to more geographically-oriented histories of the sciences and geography such as those undertaken by Charles Withers, David Livingstone, Miles Ogborn, Robert Mayhew and Felix Driver which situate geography and the sciences as formal subjects within a broad range of enlightenment intellectual endeavours. Education, in its various forms, from professional training to amateur accomplishment, is assuming a central role in the expansive field of eighteenth-century studies, particularly those which address issues of improvement and enlightenment. The analysis of scientific and geographical education addresses

some broad issues concerned with concepts of nation, nature, modernity, childhood, the public sphere and polite society and is affiliated to recent cultural histories of Georgian England such as those by John Brewer, John Barrell and Ann Bermingham, especially as it addresses the complications of a consciously commercial society.[1] History of education is therefore shown to be integral to the wider study of history, and that wider understanding of history indispensable for an appreciation of educational change in this period.

Geography, the sciences and the growth of English power

The expansion of the English economy, growth of global trade, development of maritime power and establishment of colonies during the seventeenth century encouraged the development of more effective commercial, charitable and governmental maritime education. Francis Bacon's famous image of the Pillars of Hercules on the engraved title page of his *Instauratio Magna* (literally, *Great New Start*) of 1620 symbolised the success of British commerce. Imperialism was believed to be driven by the advancement of learning which was in turn stimulated by the development of colonies and naval power in a kind of virtuous circle. The successful operation of new international joint-stock trading concerns with investors pooling their risks like the East India Company (founded 1600) and Royal Africa Company (founded 1660) required effective merchant marine and naval support to protect and expand burgeoning maritime trade routes and exploit fresh resources and opportunities, utilising their heavily armed merchantmen (Figure 1). Goods such as sugar, tobacco, timber, furs, textiles, raw materials for medicines, 'new' plants and spices flowed through British home and colonial ports, especially Bristol, Liverpool, Hull and largest of all, London, which grew into the largest European hub of global trade. Likewise, the brutal slave trade, at its height during the 'long' eighteenth century, which forcibly transported thousands of slaves across the Atlantic from Africa and carried materials like cotton and sugar to Europe, required considerable investment in seamanship and vessels.[2]

However, growing international competition and rivalry brought frequent wars with the Spanish and then the French and Dutch during the seventeenth and eighteenth centuries as nations fought for control of lucrative resources and global maritime

trading opportunities. Whilst there were some tremendous British successes, there

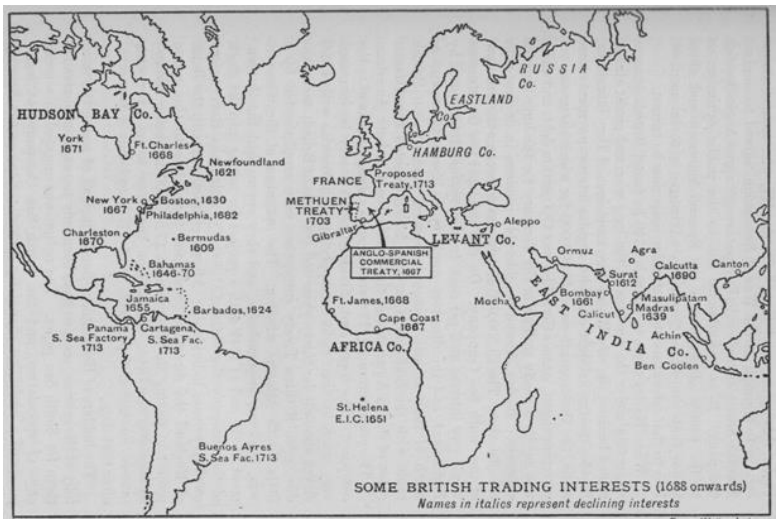

Figure 1: British global trading interests and companies by 1715 from S. Maccoby, *Eighteenth Century England* (1931)

were also failures, such as the victories facilitated by the French during the American War of Independence.[3] This meant that, as John Bettesworth and Henry Fox observed in their treatise on naval education (1782), it was so obvious as to scarcely need saying and accepted by 'Every Briton' that the 'national Glory of England, her Dignity, Power and Opulence' and the advantages accruing from her 'extensive commerce' were fundamentally supported by her 'MARITIME Strength' which if she ever lost her 'Superiority of the Seas' would render her insignificant and contemptible in the eye of nations. This 'critical' national imperative for the 'Preservation and Increase' of the Navy and 'Sovereignty of the Seas' which 'hostile' overseas enemies 'strain every Nerve to destroy' required that 'the 'Improvement of NAVAL Science' through maritime education be secured through provision of academies and instruction of all branches of knowledge required for 'expert and able Sea Commanders'.[4] Despite its extensive coastlines and nautical knowhow, in some respects the British Isles had disadvantages as a naval power. There were constant concerns over dwindling supplies of home-grown timber, driving campaigns to replenish national stocks through afforestation and searches for new supplies in North America and the Baltic. With prosperity and defence of the nation at stake, the practical elements of seamanship were crucial to the nation's wealth and survival and there was also a premium placed upon innovations that would improve these. These

factors meant that more effective methods of nautical navigation and better teaching of these methods were required.

Teaching navigation to naval and merchant marine officers included providing them with skills as artists and draughtsmen so they could draw geographical features of new lands like coasts and cliffs, ports and harbours, fortifications, mountains, trees, and buildings so location and harbours could be more effectively charted and identified. Effective teaching of astronomy and navigation required familiarity with equipment such as drawing tools, maps and charts, globes, compasses, astrolabes, quadrants, armillary spheres, terrestrial and celestial spheres. Prospective officers needed to learn the elements of the sphere, how to understand, use and draw naval charts, atlases and astronomical and cosmographical information like solar cycles, the movements of tides and currents (hydrography), plotting location (latitude) with compasses and quadrants. (Figure 2). There were fears that other nations, especially the French and Dutch, might overtake the British by improving their technical capabilities, quality of construction of merchant and naval vessels, navigation skills and education of seamen. For example, although it took a long time to implement in practice, Jean-Baptiste Colbert's ambitious programme to implement a 'Gardes de la Marine' with its own academies and professors from 1681 in major ports teaching navigation, hydrography, gunnery, ship construction and related subjects was intended to revitalise the French navy.[5] Citing the example of the French 'Gardes de la Marine', in his *Essay on the Usefulness of Mathematical Learning* (1700), John Arbuthnot (1667-1735), the Scottish physician and writer, called for improvements in British naval education.[6] Likewise, again highlighting French efforts to improve naval education, between 1699 and 1704 the writer and philanthropist Lewis Maidwell (1650-1716) sought to establish an English school for the 'sea service of the nation' to teach practical mathematics, navigation and other subjects, but the project foundered despite support from the Admiralty (Figure 3).[7]

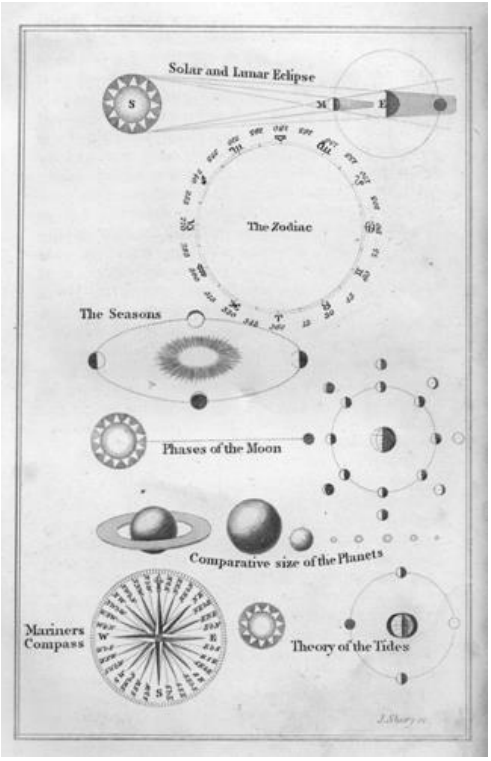

Figure 2: Astronomical and navigational diagrams from Rev. J. Goldsmith [R. Phillips], *A Grammar of Geography for the Use of Schools*, improved and enlarged by G. N. Wright (c1840)

Figure 3: The destruction of Sir Cloudesly Shovell's fleet in 1707 from A. S. Turberville, *English Men and Manners in the Eighteenth Century* (1926)

Teaching geography and the sciences

Geography and the sciences were everywhere in eighteenth century England as subjects of learning, in schools of all kinds, also homes, gardens, libraries, museums, theatres, shipboard and in excursions in both country and city, both within and beyond Britain. However, the two universities of Oxford and Cambridge placed a greater emphasis upon classical learning and theology during the second half of the eighteenth century. Nevertheless, as Hans and others have demonstrated using biographical information primarily derived from the original edition of the *Dictionary of National Biography* (1885-1900), whilst there was a tendency for professors appointed to scientific chairs not to lecture on their subjects at Oxford and Cambridge, these institutions did teach elements of the sciences and geography as part of their course on 'Philosophy', using textbooks such as the mathematician, geographer and theologian Rev. Edward Well's *Treatise of Ancient and Present Geography* (1701) and historical geographies of the New and Old Testament (1708, 1711-12).[8]

The general usefulness of geography to different segments of society and how it inhered with other subjects and practical endeavours was emphasised by Peter Heylyn (1600-1662) in his *Cosmographia* (1657), which was strongly influenced by Francis Bacon and much reprinted into the eighteenth century. Information from Heylyn was much recycled in cheaper books printed and marketed at those who could not afford the original lavish thick folio tome. For Heylyn, cosmography was the 'universal comprehension of natural and civil history', combining geography with natural history, civil history, practical mathematics, astronomy and climate. Geography was 'exceedingly useful' for teaching the holy scriptures, providing accounts of Biblical countries and the travels of prophets and apostles. The subject was also beneficial for astronomers who could learn different stars in different countries and their relative motions, and to physicians whose neo-Hippocratic understanding enabled them to appreciate 'the different temper of men's bodies, according to the climes they live in and furthermore, the 'nature and growth of many simples and medicinal drugs'. Equally to 'Statesmen', the subject demonstrated the 'nature and disposition of those people with whom they negotiate' and the extent and character of their own states and other countries 'both by sea and land'. Likewise, for merchants, mariners and soldiers,

they required a ‘competent knowledge in geography which presents to them many notable advantages both for their profit and entertainment.’ [9]

There were many modes and combinations of geographical and scientific education, including exercises on globes (celestial and terrestrial), map work (both reading and drawing), rote learning, game playing, dramatic performing, field observation, specimen collecting (from rocks and minerals to plants) and topographical sketching (Figure 4). This was a multifarious and fluent geography: pupils and teachers shifted between sites, some schools were short-lived, other teaching and learning occurred on board ships or military campaigns. Some modes remained more uniform throughout the century and between different types of learning; others expressed particular pedagogical views. A crucial dimension we will explore are the material as well as intellectual aspects of scientific and geographical learning, including the making and marketing of textbooks and equipment and the design and management of places of learning.

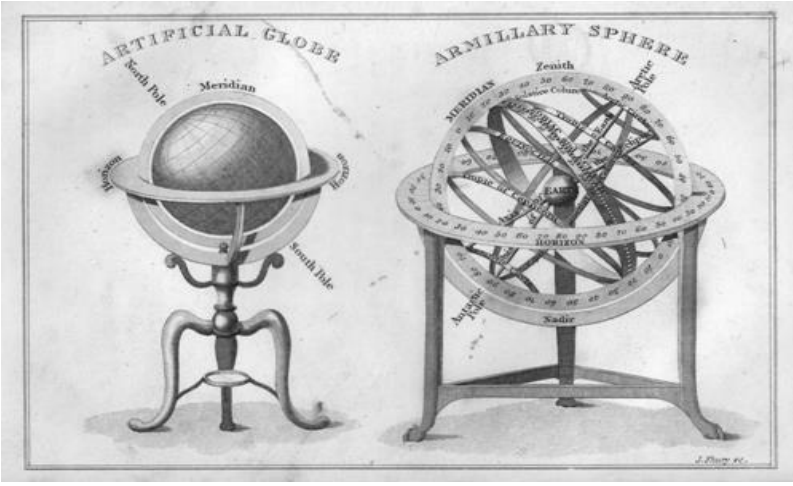

Figure 4: Globes from Rev. J. Goldsmith [R. Phillips], *A Grammar of Geography for the Use of Schools*, improved and enlarged by G. N. Wright (c1840)

Naval and military education

The growth of British trade and empire had a profound impact upon Georgian geographical education, most obviously by stimulating the development of an

extensive network of mathematical, naval and military schools teaching navigation and related subjects such as practical mathematics, astronomy and engineering. Backed by patriotic endeavours, a premium was placed upon the acquisition of superior mathematical and geographical education to facilitate British competition with major European powers. There was considerable crossover between nautical navigation and land-surveying, given the similar skills and knowledges required for each. Both astronomical and mathematical knowledge were needed for determining longitude and latitude for instance, the principles for which were the same on sea or land. Furthermore, the eighteenth-century British navy played a large role in conducting global surveys, including charting coastlines and inland and producing maps for the benefit of future naval, trading and scientific expeditions (Figure 5). The distinction between military and civilian was blurred in this period. Many officers were educated in schools and academies intended for professionals. Trading concerns such as the East India Company retained naval and military forces and employed surveyors and cartographers, whilst remaining officially, private companies with shareholders. The Royal Navy and trading associations like the East India Company conducted extensive maritime, coastal and terrestrial surveys such as those undertaken by the geographers James Rennell (1742-1830) in India and Alexander Dalrymple (1737-1838) across Asia and the Pacific, producing charts and facilitating astronomical observations. Naval vessels for exploration and surveying, like the Investigator commanded by Mathew Flinders (1801), headed for the South Seas equipped with the most sophisticated sextants, chronometers and mathematical and astronomical instruments, the latest charts provided by Aaron Arrowsmith, a library, quarter-deck greenhouse to shelter living specimens, the botanist Robert Brown, astronomer John Crosley, landscape painter William Westall, plus a botanical artist, gardener and miner. Officers, the majority of whom were from the landed classes, encouraged acquisition of practical mathematical, geographical and astronomical skills for navigation and surveying. As the mapping of the Scottish Highlands and provision of forts and roads to drive forcible assimilation after the defeat of the Second Jacobite Rebellion at Culloden in 1745 demonstrates, surveying and engineering were viewed as part of military practices. Astronomical and mathematical geographical education came to be regarded as integral to British citizenship, helping to explain why study of subjects such as navigation were studied in inland locations.[10]

Encouraged by Sir John Moore (1617-79) a mathematician and governor of Christ's Hospital, London, a Mathematical School was established as part of the original grammar school in 1673 during the reign of Charles II to instruct forty poor boys on the foundation and many others funded by private bequests from the ages of around 12 to 17 in navigation and arithmetic. Ten were taught until sufficiently qualified to be initiated into the navigation practices and serve as apprentices to Royal Navy ship commanders for seven years, whilst others served on merchant ships or became tutors aboard naval vessels. Christ's Hospital School was intended to further the development of mathematical and geographical education to facilitate trade and naval competition with rival European powers. It was also promoted by fellows of the Royal Society with naval and philosophical interests, notably Samuel Pepys and Christopher Wren, and served as an excellent example of the utilitarian and patriotic value of Baconian natural philosophy to facilitate the growth of British trade and the empire.

Figure 5: Map of the West Indies from R. Brookes MD, *A General Gazetteer of Compendious Geographical Dictionary*, fifteenth edition (1823)

The Mathematical School was provided with a library, globes, maps and mathematical instruments and boys were encouraged to remain until age16. Astronomy was taught in practical ways with boys sitting up at night to observe the rising and falling of the moon and stars on clear nights.[11] Isaac Newton subsequently

supported the appointment of Humphrey Ditton (1675-1715) as master of a second mathematical school at Christ's Hospital. The latter was the author of various mathematical and philosophical works, including a *New Method for Discovering the Longitude both at Sea and Land* (1714). Masters at Christ's Hospital included prominent mathematicians and natural philosophers included James Hodgson FRS (1672-1755), John Robertson FRS (1712-76), James Dodson FRS, 1755-7, author of books on navigation, astronomy and cartography, and William Wales FRS, co-navigator for James Cook between 1775-99. Subjects taught included trigonometry, geometry, astronomy, navigation, surveying and geography and a pair of globes was purchased in 1705 at a cost of £5 with a model ship for 23 guineas.[12] A good indication of the school's impact upon scientific and geographical knowledge and education is the number of commercial and grammar schools following a similar plan in its wake across Britain and Europe. Students included the natural philosopher James Jurin FRS (1684-1750) who became a master at Newcastle Grammar School (1709-15) and served as Secretary of the Royal Society. Another former pupil Thomas Crosby published the *Mariner's Guide* (1751), a textbook on navigation and kept a mathematical school in Southwark (1710-1750) which taught mathematics, geometry, plain and spherical trigonometry, navigation and astronomy.[13]

Another naval school established in the latter seventeenth century which taught geography and some scientific subjects was the Greenwich Hospital School. According to the 1694 charter, the school was intended for the maintenance and education of children of injured or slain seamen, the relief and encouragement of seamen and the 'improvement of navigation', and it was organised in a similar way to Christ's Hospital Mathematical School. Although pupil numbers fluctuated from the hundred envisaged in 1712 to sixty in 1731 and two hundred by 1803, the emphasis upon mathematical education was strong with training for the merchant service and the navy. The School provided master's assistants who studied for two to three years and eventually became captains, sometimes admirals, and was sufficiently well regarded that sons of officers in mercantile marine and commissioned navy officers gained admission from 1732 onwards. Although the plan in 1728 to equip two rooms with 'Books, Maps, Charts' and models of ships for teaching mathematics and navigation does not appear to have been fully implemented, it demonstrates the direction the curriculum was taking.[14]

Established in 1729 and opened in 1733, the Naval Academy at Portsmouth provided a similar mathematical and nautical education to the Greenwich Hospital School for 40 young sons of nobles and gentlemen aged 12 to 15 who volunteered for the navy. Prior to this, youths either became naval officers by gaining an education aboard ship overseen by a schoolmaster, becoming one of the captain's servants or, from 1676 by serving on board ship as volunteers-per-order. Although there were never as many pupils as originally hoped, disciplinary problems occurred and some naval officers were against shore-based education, the boys were taught navigation and other subjects by a resident master and instructors.[15] In 1773, reforms were implemented which saw provision expanded to boys aged 11 to 17, and the two to three years spent at the Academy counted towards qualification for the lieutenant's examination. Fifteen places were provided on a public scholarship for sons of sea officers, an innovative example of taxpayer's funding for teaching 60 years before the first government grant for education in 1833.[16]

As at Christ's Hospital Mathematical School, some of the Portsmouth Academy staff were academically well qualified to teach geography and the sciences and had considerable experience and standing as astronomers, mathematicians, navigators and natural philosophers with close links to the Navy and Royal Society. These included Thomas Haselden FRS (d1740), master between 1733 and 1740, John Robertson FRS (1712-76), headmaster between 1755 and 1766, and George Witchell (1728-85). Witchell was hired as a computer (calculator) working for the Astronomer Royal Nevil Maskelyne (1732-1811) on the first annual Nautical Almanac published by the Board of Longitude, and his work helped it to improve the accuracy of astronomical observations using better calculations of Lunar distance.[17] After returning from his second voyage on the Discovery in 1775, James Cook sought assistance from Witchell to check his chronometer using Portsmouth Academy's Observatory equipment and two other masters were closely involved with international astronomical observations and Cook's expeditions. The astronomer, William Bayly (1737-1810), who had been a Bristol schoolmaster and was assistant at the Royal Observatory under Maskelyne, served as master between 1785 and 1807. On the recommendation of Maskelyne in 1769, Bayly went to North Cape, Norway for the Royal Society to observe the transit of Venus, and in 1772 was an astronomer on Cook's second voyage of discovery to the southern hemisphere. Bayly also joined

Cook's third and final voyage with the Resolution and the Discovery (1776-80), which resulted in Cook's death. Bayly's journal of the expedition across the Pacific Islands and west coast of North America is preserved in the National Archives at Kew.[18] Finally, Rev. James Inman (1776-1859) served as astronomer under Matthew Flinders on board HMS Investigator in 1803-4 charting the sea around Australia. Inman published a book on nautical and navigational astronomy (1821), was Professor of Nautical Mathematics at Portsmouth from 1808 and helped initiate the first school of Naval Architecture there in 1810.[19]

Although all the masters' knowledge and experience did not automatically translate into effective learning and the school experienced some problems, the approach to teaching geographical and scientific subjects, as well as practical seamanship and navigation led by masters, boatswain and schoolmaster was quite innovative. The mathematician John Robertson's much re-published *Elements of Navigation* (1754), which was originally intended for the use of pupils at Christ's Hospital Mathematical School, provides a good indication of the curriculum there and at the Portsmouth Academy. Robertson, who also produced a book on portable mathematical instruments and their uses in geography, surveying, architecture and marine navigation, had previously served as headmaster of the Christ's Hospital Mathematical School and subsequently became clerk and librarian to the Royal Society. His *Elements of Navigation* included a dissertation on the 'Modern Art of Navigation' and chapters navigation, arithmetic, geometry, plane trigonometry, spherics, astronomy and geography with fold-out maps, tables and numerous diagrams. Boys practised the nautical rigging and construction demonstrated on vessels where they practised, staying for two to three years which counted towards their six years as midshipman to become a lieutenant. The curriculum included writing, arithmetic, drawing, navigation, gunnery, fortification and practical mathematics and the Academy continued to supervise former students whilst at sea. When ships returned to Portsmouth, volunteers were required to present their journals to the Academy's Master who inspected them and reported to Secretary of the Admiralty. Volunteers continued their education at the Academy free of charge if certified by their captain for good behaviour. Aboard ship, they were required to keep their journals going drawing maps and making sketches of coastlines, headlands, bays and other geographical features following captain's directions.[20]

A practical geographical education intended primarily for those in the army was pursued at the Woolwich Academy. Mathematical tutors at Woolwich included Charles Hutton (1737-1823), John Bonnycastle (1750-1827) and Thomas Myers (1774-1834) who all published works on geography, mathematics and related subjects. Hutton's *Course of Mathematics for the use of Cadets in the Academy* (1798-1801) and Myers' *Compendious System of Modern Geography* (1812) demonstrate the content of the curriculum and other commercial schools and tutors offered learning modelled upon that at Woolwich.[21] The Belgian Lewis Lochée (d1791) for instance, was proprietor and master of a military academy at Little Chelsea during the 1770s and 1780s which, he claimed in his *Essay on Military Education* (1773), operated like a 'military republic', teaching history, geography, cartography, military drawing and other components martial sciences.[22]

Hundreds of tutors and private academies across the British Isles and North American colonies taught mathematical geography, astronomy, navigation and related subjects. There was, of course, a concentration of those teaching marine subjects in coastal towns. However analysis of school advertisements and textbooks reveals that these subjects were also taught inland. Natural philosophy was taught at an academy on Little Tower Street, London by Benjamin Worster during the 1720s where courses in experimental philosophy with demonstration experiments were conducted to qualify 'young gentlemen' for business away from 'interruptions' in 'common schools'. Besides mathematics, French, drawing and natural philosophy including hydrostatics, the Newtonian system, optics, mechanic and pneumatics were taught.[23] Another mathematical school was founded at Rochester by Sir Joseph Williamson and appointed John Colson (1680-1760), the future Lucasian Professor of Mathematics at Cambridge, as master. Colson translated mathematical and philosophical texts and published a work on 'the construction and use of the spherical maps' (1736). Geography, gauging, surveying, navigation and natural philosophy were taught at the Soho Academy conducted by Martin Clare FRS the author of *The Motion of Fluids* (1735) using globes and a large library. Another mathematical school was conducted by the mathematician, Charles Hutton, in Newcastle between 1760 and 1773, the author of *The Schoolmaster's Guide* (1764), who used the institution to deliver public lectures on geography and astronomy. Mathematical geography was an important feature of the education provided in the major British ports such as Bristol and

Liverpool. The Irish educationist, David Manson, taught mathematical navigation to sailors in Liverpool until 1752, charging fees of 6d per hour.[24] At Kingston near Taunton, Somerset and subsequently Bristol, mathematical academies were managed by the scientific lecturer Benjamin Donn (1729-1798), a surveyor, cartographer and author of works on globes and nautical apparatus including the *British Mariner's Assistant* (1774) and *An Epitome of Natural and Experimental Philosophy* (1769) for the use of schools and 'Young Ladies and Gentlemen'.[25]

Some geographical and scientific subjects regarded as essential for the nation's maritime success were taught on board ship. Most education for those intending to be royal naval officers was done this way by schoolmasters who also taught other young seamen on vessels. Between 1712 and 1824, some five to six hundred schoolmasters were working on British ships and over 1,000 warrants were issued by the Admiralty sanctioning this. Similar teaching had occurred in less systematic fashion at the expense of captains the previous century. Henry Knight, a ship's schoolmaster recorded in 1704, was taught at Christ's Hospital and taught navigation on board the Dorsetshire. Future officers gained on-service training on board ship by enjoying the patronage of captains as 'servants' or following reforms undertaken by Samuel Pepys in 1676, as 'Volunteers per-Order'. Captains could have four servants per hundred crew or eight if they were a knight or nobleman, whilst they were obliged to take on volunteers per-order aged up to 16 who aimed to become officers. Both kinds of prospective officers had to be sufficiently skilled in the 'art and practice of navigation' and to improve their seamanship and navigation skills enough to pass their examination and be promoted from midshipman to lieutenant. From 1702, the system of schoolmasters on board vessels was formalised so 'young gentlemen' received training in the practical parts of seamanship and navigation. Schoolmasters received an additional £20 per annum above midshipman pay if on board third-, fourth- or fifth-rate ships, and eventually all rating of ships and needed to have obtained a qualification certificate from the Trinity House Corporation.[26]

Innovative methods for teaching astronomy, mathematical geography, surveying and navigation included the use of novel apparatus, topographical field-sketching, the employment of schoolmasters on military campaigns and naval vessels. There were also naval and military editions of various works. These included special editions of

travel literature such as the expeditions of James Cook, gazetteers and novels intended to further geographical education (Figure 6).[27] An unusual example was an edition of Daniel Defoe's *Robinson Crusoe* published in 1815 'revised and corrected' for 'nautical education' which was 'illustrated by technical and geographical annotations and embellished with maps and engravings' by the Hydrographer of the *Naval Chronicle*, with extensive footnotes and appendices on hydrography, natural history and scientific subjects.[28] The *Complete Geographical Dictionary* (1787) by Rev. John Seally FRS (1742-95) included maps and descriptions of Cook's expeditions in addition to the usual summaries of ancient and modern geography in alphabetical form with engravings of places, astronomical and chronological tables, and extracts from the private papers of one of Cook's officers. Seally established an academy at Bridgewater Square in London which taught ancient and modern languages, history, mathematics, geography, astronomy and natural philosophy, and the accounts of voyages and astronomical information were utilised in his teaching.[29]

Figure 6: Engravings of Sweden and Russia from Rev. J. Goldsmith [R. Phillips], *A Grammar of Geography for the Use of Schools*, improved and enlarged by G. N. Wright (c1840)

Domestic scientific and geographical education

In a culture suspicious of the corruptions of institutional life, the ‘home’ remained a model site of learning, influencing the design and management of many schools. Texts and pictures emphasised the virtues of domesticity in geographical and scientific learning, not just in and around the home but on family excursions (Figure 7). Family values in geographical and scientific education took a variety of ideological forms, from the model of the royal family (both of George III and Louis XVI of France) to the international kinship networks of religious dissenters. The cult of motherhood profoundly shaped pedagogy, especially in some progressive texts, where ‘the home’ served not as an introverted retreat from the world, but a public vantage point for its comprehension. Key images of geography and the sciences in the home included pictorial conversation pieces and childhood primers. As the depiction of the figure of ‘Geographia’ herself demonstrates, there was a pronounced feminine iconography of geographical learning, also evident in the figure of the mother-educator. Evidence of geographical and scientific teaching and learning survives in archival records such as diaries and memoirs which show very well how reading, demonstration, excursions and other activities such as solving problems with globes and assembling dissected maps (or jigsaws) were often used to teach these subjects. Scientific and geographical learning took place in a variety of domestic places and spaces and different rooms around the home including nurseries, libraries and gardens.

Figure 7: Children being taught geography from Rev. J. Goldsmith [R. Phillips], *A Grammar of Geography for the Use of Schools*, improved and enlarged by G. N. Wright (c1840)

The sciences and geography in grammar schools

The sciences and geographical education, with their mix of humanistic and commercial learning, complicated the differences between types of institution: grammar schools, commercial schools, dissenting academies, schools for boys and girls. Older scholarship in history of education understood Georgian grammar schools as conservative institutions, obsessed with ancient languages, repetitive rote learning and ossified curricula, constrained by the dead hand of ancient statutes which masters were required to follow in return for their payment. However, whilst there is some truth in this generalisation, the needs of commerce and industry, colonialism and polite society encouraged a demand for what were perceived as 'modern' subjects. In the competitive eighteenth-century educational marketplace, commercial academies and tutors marketing their services strove to compete with grammar schools by claiming that they provided a much rounder education, more relevant to the modern age with practical modern subjects such as the sciences, geography and modern languages. Jolly B. Florian in 1796, for example, argued that his academy rectified the defects of traditional grammar school education by making 'Philosophy and the sciences' the 'principal study of young persons', that is both boys and girls, between the ages of seven and seventeen.[30]

Furthermore, as the research underpinning Edward Gibbon's *Decline and Fall of the Roman Empire* (1776-89) demonstrates so well, biblical and classical scholarship and ancient history (and perceptions of these endeavours) were themselves undergoing profound changes during the 'long' eighteenth century which impacted upon materials used for teaching these in schools such as textbooks, grammars and maps.[31] Hence although Robert Mayhew was right to emphasise that there was much continuity in the Early-Modern humanist textual geographical tradition as it impacted upon grammar schools, we should recognise the variety of ways in which geography and the sciences impacted upon learning in these institutions. Whilst, therefore, in principle so-called 'modern' subjects such as geography, astronomy, natural philosophy and natural history might appear not to have featured in most grammar school classical humanist curriculums, in practice they became part of teaching in some institutions, both formally and informally. In response to both the intellectual inclinations of masters and the local demand of parents, ways were found to

circumvent statutes against modern subjects (for example, by offering other subjects as an optional extra for additional charges), and innovations in teaching, included visual aids and dramatic performances, although this was a contested process which also attracted some opposition. The rhetoric against grammar schools used by some dissenting educationalists and commercial tutors, therefore, masks a much more varied and complex situation in relation to both grammar schools and nonconformist academies. In the latter, there was in many cases a continuing belief in the value of classical education even though modern subjects were key to how they marketed themselves against grammar schools.

Studies of classical geography were regarded as an essential component of classical education and must have been given in most schools, even if they could not afford expensive works such as some editions of classical geographers or the grammar school master William Hill's *Dionysius Orbis Descriptio Commentario Critico et Geographico* (*Dionysius' Description of the World with a Critical and Geographical Commentary*) of1658 with Greek and Latin texts, notes and clear copper plate maps, which went through various editions and was used in many schools.[32] Whilst such books and maps tended to be prohibitively expensive during the eighteenth century, the publication of abridgements and cheaper editions of popular illustrated works such as Georges-Louis Leclerc, Comte de Buffon's *Natural History* (1749-88), Oliver Goldsmith's *History of the Earth and Animated Nature* (1774) and geographical grammars helped make geography and the sciences more accessible to grammar school pupils and wider readers (Figures 8 and 9).[33]

The general usefulness of geography to different segments of society and how it inhered with other subjects and practical endeavours was emphasised by Peter Heylyn (1600-1662) in his *Cosmographia* (1657), which was strongly influenced by Francis Bacon and much reprinted into the eighteenth century. The information was also often recycled in cheaper works printed and marketed at those who could not afford the original lavish thick folio tome. For Heylyn, cosmography was the 'universal comprehension of natural and civil history' combining geography with natural history, civil history, practical mathematics, astronomy and climate. Geography was 'exceedingly useful' for teaching the holy scriptures, providing accounts of countries mentioned in the Bible and the travels of prophets and apostles. The subject was also

beneficial for astronomers who could learn different stars in different countries and their relative motions, to physicians whose neo-Hippocratic understanding enabled them to appreciate 'the different temper of men's bodies, according to the climes they live in and, furthermore, the 'nature and growth of many simples and medicinal drugs'. Equally to 'Statesmen', the subject demonstrated the 'nature and disposition of those people with whom they negotiate' and the extent and character of their own states and other countries 'both by sea and land'. Equally, for merchants, mariners and soldiers, they required a 'competent knowledge in geography which presents to them many notable advantages both for their profit and entertainment'.[34]

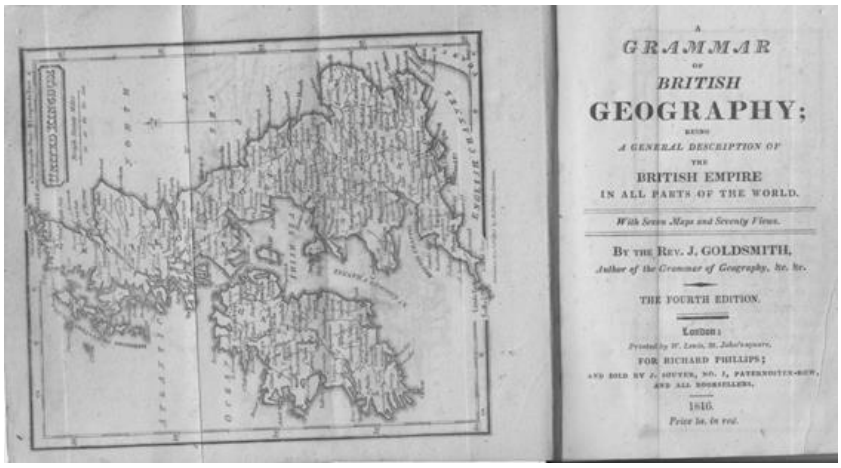

Figure 8: Frontispiece and map of the British Isles and Ireland from Rev. J. Goldsmith [R. Phillips], *A Grammar of British Geography,* fourth edition (1816)

The teaching of geography and astronomy in some grammar schools was long established and evident in their interior furnishing and decoration, with Francis Bacon remarking in the *Advancement of Learning* (1605) that 'spheres, globes, astrolabes, maps and the like' were now provided in many colleges as 'appurtenances to astronomy and cosmography, as well as books'.[35] According to Charles Hoole, the upper story of grammar schools should have a 'fair, pleasant gallery wherein to hang maps and set globes, and to lay up such rarities as can be gotten in presses or drawers, that the scholars my know them', whilst a large map of the world was hung on the north wall of Winchester College by around 1660.[36] Two eighteenth-century institutions where geography and astronomy became significant subjects were Hull Grammar School when John Clarke was master and Gresham's School, Holt, Norfolk under John Holme. Both these masters promoted their views to a wider audience by

authoring pedagogical treatises. At Gresham's School, which was governed by the London Fishmonger's Company, astronomy, geography and the study of the globes were introduced using practical activities, and encouragement was given for pupils to employ maps and their senses whilst travelling, along with globes, packs of cards and interesting stories in the classroom to help memorise the information. Dramatic performances of 'verses declamations and orations' were presented in front of friends, family and school benefactors at Christmas and other times, with pupils personified as divine beings in costumes and wigs to celebrate their progress, with the school's geographical and scientific instruments and maps used as props.[37]

The subtle ways in which natural philosophy might feature as part of grammar school education, even when not formally part of the curriculum, are evident from the achievements of Chesterfield Grammar School, Derbyshire under William Burrow who served as usher between 1711 and 1722 and headmaster from that year until 1752. Whilst the curriculum never formally changed in this period, the success of the school is evident from the number of boys who were sent at this time to Cambridge University which was far more than any other in the county. Pupils included the future physician and natural philosopher and Lunar Society founder Erasmus Darwin (who proceeded to Cambridge and Edinburgh University), his older brother the landowner and botanist Robert Waring Darwin, author of *Principia Botanica* (1787), the antiquarian Samuel Pegge (1733-) and the medical men John Stubbinge (1704-34) and Charles Balguy who became a secretary of the Peterborough Gentlemen's Society and member of the Spalding Gentlemen's Society, and published classical and medical works. The inspiration that Erasmus Darwin received from Burrow and respect in which he held him is evident from surviving correspondence with him. We learn from correspondence in 1736 and 1737 concerning another pupil William Farington that, besides the expected Latin translation exercises and reading of classical works, Farington had a 'genius for drawing' an aptitude for poetry and discussed 'Natural Philosophy, and other ornamental studies' with one of Burrow's sons who 'endeavoured to form in him proper thoughts and notions of em' which would make him a 'good Scholar and a fine Gentleman'.[38]

At Cheam School in Surrey, in the years before he found fame as the leading exponent of the picturesque movement, Rev. William Gilpin (1724-1804) strove to

provide a more practical education for his pupils founded on commercial principles more adapted for ‘landholders, tradesmen’ and those intended for ‘public officers’ combining the methods of business schools with the classical learning of ‘boarding schools’. Treating the school as a miniature ‘state’ and adopting the language of statehood, pupils were provided with garden plots to grow fruit and vegetables, whilst, in addition to the usual Greek and Latin, the curriculum included arithmetic, geography, and drawing. Geography was taught using what were called ‘dissected’ maps of counties made into jigsaws, and in 1765 one pupil had to ask his parents for a replacement for the Flintshire piece which he had lost! Presaging Gilpin’s later career as the leading English topographer, the boys were encouraged to ride and ramble around the local country, and with help from his brother Sawrey, much emphasis was placed upon expeditions where they drew what they observed in the surrounding countryside from nature.[39]

Figure 9: Frontispiece of *Buffon’s Natural History Abridged*, 2 vols., (1792), a work often recommended for use with children and young people

The sciences, geography and dissenting education

Whilst there were differences between denominations, the education promoted by Protestant dissenters or nonconformists was distinctive in supporting personal, cultural, spiritual and social development, and forms of progressive citizenship. The

sciences and geography were prominent components of dissent's new map of learning. Despite civil restrictions, and the sharpening sectarian lines at the end of the century, dissenters were a powerful cultural force, strongly involved in local government, especially of expanding commercial towns. They networked internationally, especially with Scotland, Holland, Switzerland and America. This geographical context, and its culture of natural enquiry, helped to establish geography as a key discipline. The writings of Isaac Watts, and later, if more contentiously, Joseph Priestley, were widely influential in protestant culture at large. Hackney College and Warrington Academy had an influence well beyond their catchments. As Priestley's career demonstrates, Presbyterian and Unitarian ministers took a keen interest in the sciences, partly because of the belief that in doing so they celebrated divine glory and the power of creation, but also because of the perceived practical advantages that the sciences were believed to have and the number of merchants, industrialists, businessmen and medical men in their congregations. One intellectual aspect that informed Unitarian theology and the approach to education was associationism. This resulted in curricula which valued the classics, but emphasised the need for a good education in other subjects such as modern languages, geography and the sciences for clergy as well as professionals. Rev. James Pilkington, minister of the Friargate Chapel at Derby, for instance, provided much information concerning natural history, geology and hydrology in his *History of Derbyshire* (1789), whilst Rev. William Wood, Priestley's successor at Leeds, was a fellow of the Linnean Society, taught natural history to the girls in his school, wrote articles on the subject for Arthur Akin's *Annual Review* and Abraham Rees' *Cyclopaedia* (1802-20).[40] Two of the most influential Unitarian educationists were John Aikin, tutor at the Warrington Academy who taught natural history and practical sciences and his sister Anna Barbauld who had a wider impact with their voluminous educational and other writings.[41]

Another striking example of a dissenting school in which the sciences and geography were taught in an imaginative, integrative and experiential manner was the Laurence Street Academy run by the Welsh educationalist David Williams. Williams offered a wide range of subjects in the curriculum including mathematics, geography, history, modern languages, moral and political philosophy, natural history, astronomy and other sciences such as chemistry. Older boys about the age of ten or so were

encouraged to pursue studies in chemistry, hydrostatics and pneumatics and critically read articles in the *Transactions of the Royal Society*, the French *Encyclopedia* and transactions of European scientific societies. Williams emphasised that natural history was the 'first pursuit of the human mind' which young children in particular had a special aptitude for, and pupils were encouraged to collect plants and other objects from the house and their locality, including different types of wood, rocks and minerals. These were used as a means of introducing different words and concepts.[42] As well as these expeditions, students were encouraged to do gardening and horticultural activities. Unlike many schools and the more common methods of teaching 'the globes', geography was not so much introduced with astronomy but through close observations of immediate domestic life, the local district and excursions further afield. The boys then used these observations to make further investigations, of the weather and climate, the oceans and the solar system which were supported by the creation of maps and the construction of globes and other mechanical devices such as clocks.[43]

Other very influential dissenting educationists who encouraged the teaching of geography and scientific subjects were John Aikin (1747-1822) and Anna Laetitia Barbauld (1743-1825), the son and daughter of John Aikin (1713-1780), tutor at the dissenting Warrington Academy. They made their names as published writers, essayists, poets and educationalists, commanding a wide, highly respectful readership in polite society; in the 1790s their work became politically contentious. In a range of writings they extended the scope and moral seriousness of geography, to consider relations of land and life, and the comparative development of the habitable world, raising its status as a subject of learning for both children and adults. They focus on the place of geographical education in both child development and adult citizenship, in particular the interaction of people with the natural world as well as each other, and the relation of things to words, objects to representations. Two institutions have a strong presence in Aikin's writings, Warrington Academy and Palgrave Academy, Suffolk where, for a period, Anna Laeititia Barbauld developed her ideas in teaching practice, giving prominence to geography as a way of developing citizenship. An expanded idea of the home and the domestic sphere is the pivot of her vision. In a series of best-selling texts (both in the US and Britain), including teaching books, children's stories, guidebooks and magazine articles published under his editorship,

John Aikin developed what he called 'the philosophy of geography', a wide-ranging, liberal vision of the world and its workings, with a strong sense of the physical environment. The geographical pedagogy of both Barbauld and Aikin was developed and popularised from the early nineteenth century in the works of John Aikins's children Lucy and Arthur Aikin. The family's enterprise was known as 'the Aikin School'.[44]

Girls' education

A well-documented example of geographical and scientific education pursued in a girl's school is the work of Margaret Bryan at Bryan House situated at Blackheath between 1795 and 1806 and subsequently Hyde Park Corner, London and then Margate from 1816. We know something about the curriculum because of Bryan's publications based upon her lectures, especially her *Compendious System of Astronomy*, *Lectures on Natural Philosophy*, *Conversations on Chemistry* and *Comprehensive Astronomical Class Book* (1815). All the diagrams and illustrations were drawn by her and presumably used in teaching and having sent the manuscript to Charles Hutton at the Woolwich Royal Military Academy, she was praised for demonstrating how even 'learned and more difficult sciences' were 'beginning to be successfully cultivated by the extraordinary and elegant talents of the female writers'. Bryan's books demonstrate that astronomy, mathematics, natural philosophy and chemistry were being taught to girls, and her works were subscribed to by some of her current and former female students, the lectures of natural philosophy by 157 women.[45] Some more information about the stages in which geographical and scientific subjects were taught at this time, and the methods used, comes from the evidence of a girl's academy conducted by Mrs Florian at her boarding school for girls at Leytonstone, Epping Forest. According to an advertisement for 'Female Education' placed in her husband J.B. Florian-Jolly's *Course of the Sciences and Philosophy* (1806), the subjects and methods were designed to make female education 'keep pace with the general diffusion and rapid progress of useful knowledge' that distinguished the current age. From the ages of around eight or nine to twelve, young ladies were taught English, French, geography and history. Geometry and trigonometry were covered to enable understanding of astronomical principles and the 'geographical knowledge of our globe and of Natural Philosophy…illustrated by

experiments and machines', whilst geographical maps formed by pupils were used to illustrate different historical periods.[46]

'Opening the Book of Nature': Pestalozzi and the teaching of geography and natural history

The idea of using the immediate environment as a tool for teaching was hardly new, and Comenius, for example, in his *Schola Infantiae* (*School of Infancy*) emphasised that young children began to learn geography as they perceived the spaces around them, discovering domestic life, fields, mountains, forest meadows and rivers. Similarly, the schoolmaster, Hezekiah Woodward (1590-1675), observed that lessons could be constructed using everyday places and events, including observing agriculture and domestic economy and horticulture, even if this was primarily to instil moral values.[47] However, in the wake of Rousseau, it was the influence of Johann Heinrich Pestalozzi (1746-1827) that led to a turn to experiential learning using the environment in British schools from the early nineteenth century. His ideas on British education became pronounced after the end of European wartime hostilities in 1815 and reformers visited Pestalozzi's model school of Yverdun and his disciple Fellenberg's school at Hofwyl. He authored texts and set up schools based on Pestalozzian ideas and practice. In turn Pestalozzi considered Britain to be constitutionally and culturally the country where his ideas could be best realised. Some key aspects of Pestalozzi's pedagogy were changed in translation, for example principles of 'spontaneity' (self activation) in Phillip Pullen's *The Mothers Book,* and Pestalozzi's *System of Practical Geography,* and the role of the local environment in Elizabeth's Mayo's writings on object lessons which became incorporated in commodity-centred colonial geographies. Some schools in and around London, for example at Cheam and Ealing Grove, incorporated Pestalozzian practice.[48] An influential exemplar is the Worksop Institution, Nottinghamshire, run by husband and wife Beatus and Adele Heldenmaier. Beatus Heldenmaier had attended Pestalozzi's Yverdun School and studied for a doctorate in Berlin where he was taught by the German philosopher Georg Wilhelm Friedrich Hegel and the geographer Carl Ritter. The Worksop Institution attracted pupils from progressive families throughout the Midlands and North of England, and some from overseas, and included field trips to both industrial and agrarian sites. There is (for schooling at the time generally) a rare

collection of letters to home by two Worksop pupils, William and Charles Marling which offer an alternative view of this highly praised institution.[49] The school became a model for later nineteenth century educational writing, notably in Herbert Spencer's *Education: Intellectual, Moral and Spiritual*. Spencer's father William George was secretary of the Derby Philosophical Society which Heldenmaier joined.[50]

Conclusion

The lessons of geography, the sciences and citizenship in eighteenth and early nineteenth century England have implications that extend beyond this period and place. They had legacy for succeeding periods of imperialism and post-imperialism in Britain and beyond and subsequent kinds of geographical and scientific education, both as formal disciplines and informal modes of learning. They framed such issues as progressive education, vocational training, nature appreciation, child development and cultural policy.

Summary points

- Many aspects of geographical and scientific education were transformed between c1680-1820 in the context of Britain's development as a dominant commercial and naval global power.
- Engagement with geographical subjects and Enlightenment sciences like astronomy, natural history and natural philosophy projected views of the nation.
- Geographical and scientific subjects were taught and encountered in formal settings like schools and universities and wider culture and society, for example, through print culture, public lectures and literary and scientific associations.
- Some geographical and scientific endeavours were pursued in informal contexts for example, as a form of accomplishment in the realm of female education in the domestic sphere.
- Encouraged by the spread of ideas and market competition, innovative methods were introduced to teach geography and the sciences including the use of maps, globes and jigsaws in schools, employment of scientific apparatus and forms of experiential learning like natural history walks, gardening and teaching on board merchant marine and naval ships.

Recommended reading

N. Hans, *New Trends in Education in the Eighteenth Century* (London, 1966)

P. Elliott and S. Daniels, ‘‘No study so agreeable to the youthful mind’: geographical education in the Georgian grammar school’, *History of Education*, (2008), 1-18.

R. Porter ed., *The Cambridge History of Science: Volume 4: Eighteenth-Century Science* (Cambridge, 2003),

D. N. Livingstone and C. W. J. Withers eds., *Geography and Enlightenment* (Chicago, 1999)

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[1] R. Mayhew *Enlightenment Geography* (London, 2000); C. W. J. Withers *Geography, Science and National Identity* (Cambridge, 2001); M. Ogborn and C. J. Withers eds *Georgian Geographies* (Manchester, 2004); A. Bermingham, *Learning to Draw* (New Haven, 2000); D. Livingstone and C. Withers eds, *Geography and Enlightenment* (Chicago, 1999); H. Guest, *Small Change: Women, Learning, Patriotism* (Chicago, 2000).

[2] C. E. Carrington, *The British Overseas: Exploits of a Nation of Shopkeepers* (Cambridge, 1950), 59-82, 141-228; D. Mackay, *In the Wake of Cook: Exploration, Science and Empire, 1780-1801* (London, 1985), 57-82, 123-43, 144-67; J. Keay, *The Honourable Company: A History of the English East India Company* (London, 1993); H. Thomas, *The Slave Trade: The History of the Atlantic Slave Trade, 1440-1870* (London, 1998); W. Dalrymple, *The Anarchy: The Relentless Rise of the East India Company* (London, 2020); P. J. Marshall and G. Williams, *The Great Map of Mankind: British Perceptions of the World in the Age of Enlightenment* (London, 1982); D. Outram, ‘On being Perseus: new knowledge, dislocation and Enlightenment exploration’, in D. N. Livingstone and C. W. J. Wither eds., *Geography and Enlightenment* (Chicago, 1999), 281-94; A MacLean, *Captain Cook* (London, 1972); D. Mackay, *In the Wake of Cook: Exploration, Science and Empire, 1780-1801* (London, 1985).

[3] N. A. M. Rodger, *The Command of the Ocean: A Naval History of Britain, 1649-1815* (London, 2006), 336-9, 341-2, 351-5.

[4] J. Bettesworth and H. Fox, *Observations on Education in General but Particularly on Naval Education* (London, 1782), 6-9.
[5] A. J. Turner, 'Advancing navigation in eighteenth-century France: teaching and instrument making in the port of Rochefort', *Mariner's Mirror*, 91 (2005), 531-547; M. Levy-Eichel, ''Suitable to the Meanest Capacity': Mathematics, navigation and self-education in the early modern British Atlantic, *Mariner's Mirror*, 103 (2017), 450-465.
[6] J. Arbuthnot, *Essay on the Usefulness of Mathematical Learning*, second edition (London, 1721).
[7] H. T. A. Bosanquet, 'The Maritime School at Chelsea, *Mariner's Mirror*, 7 (1921), 322-329, pp. 323-4; F. B. Sullivan, 'The Royal Academy at Portsmouth 1729–1806', *Mariner's Mirror*, 63 (1977), 311-26, pp. 312-13.
[8] N. Hans, *New Trends in Education in the Eighteenth Century* (London, 1966), 31-6, 41-54, 136-60; L. Brockliss, 'Science, the universities, and other public spaces: teaching science in Europe and the Americas', in R. Porter ed., *The Cambridge History of Science: Volume 4: Eighteenth-Century Science* (Cambridge, 2003), 44-86; S. Woodley, ''Oh miserable and most ruinous measure': the debate between private and public education in Britain, 1760–1800' in M. Hilton and J. Chefrin eds., *Educating the Child in Enlightenment Britain: Beliefs, Cultures, Practices* (Farnham, 2009), 21-40.
[9] P. Heylyn, *Cosmographie…Containing the Chorography and History of the Whole World* (1657) quoted in F. Watson, *The Beginnings of the Teaching of Modern Subjects in England* (London, 1909), 125-8.
[10] MacLean, *Captain Cook*; Marshall and Williams, *Great Map of Mankind: British*; Mackay, *Wake of Cook*, 3-5, 168-91; Keay, *Honourable Company*, 353-61; D. Outram, 'On being Perseus: new knowledge, dislocation and Enlightenment exploration', in D. N. Livingstone and C. W. J. Wither eds., *Geography and Enlightenment* (Chicago, 1999), 281-94; J. Bonehill and S. Daniels eds., *Paul Sandby: Picturing Britain* (London, 2009), 13-16, 74-102; Dalrymple, *The Anarchy*, 238.
[11] E. H. Pearce ed., *Annals of Christ's Hospital* (London, 1901), 110; Watson, *Beginnings of the Teaching of Modern Subjects*, 391-3
[12] Watson, *Beginnings of Teaching Modern Subjects*, 105; N. F. Ellerton and M. A. Clements, *Samuel Pepys, Isaac Newton, James Hodgson, and the Beginnings of Secondary School Mathematics: A History of the Royal Mathematical School Within Christ's Hospital, London 1673–1868* (Cham, 2017).
[13] T. Crosby, *The Mariner's Guide: Being a Compleat Treatise on Navigation* (London, 1751); Hans, *New Trends in Education*, 38-9, 107, 213-19.
[14] N. Macleod, 'History of the Royal Hospital School', *Mariner's Mirror*, 35 (1949), 182-202.
[15] F. B. Sullivan, 'The Royal Academy at Portsmouth 1729–1806', *Mariner's Mirror*, 63 (1977), 311-326; H. W. Dickinson, *Educating the Royal Navy: Eighteenth – and Nineteenth-Century Education for Officers* (Abingdon, 2007), 9-56; J. H. Thomas, 'Portsmouth Naval Academy in the age of Nelson: a reassessment', *International Journal of Maritime History*, (2011), 23.
[16] C. Lloyd, 'The Royal Naval colleges at Portsmouth and Greenwich', *Mariner's Mirror*, 52 (1966), 145-156; Dickinson, *Educating the Royal Navy*, 9-56
[17] Sullivan, 'Royal Academy at Portsmouth', 322-3; notes on Witchell's career by Alexi Baker, Royal Greenwich Observatory Archives, https://cudl.lib.cam.ac.uk/view/MS-RGO-00004-00292/1, accessed 18 June 2022.

[18] Log kept by William Bayly, (1776 Aug 1-1779 Dec 3), The National Archives, Kew, ADM 55/20; Sullivan, 'Royal Academy at Portsmouth', 323.
[19] J. Inman, *Navigation and Nautical Astronomy: For the Use of British Seamen,* first edition (London, 1821).
[20] J. Robertson, *A Treatise of Such mathematical Instruments as are usually put into a Portable Case*, third edition (London, 1775); J. Robertson, *Elements of Navigation*, fourth edition, 2 vols., (London; J. Nourse, 1780); J. Robertson and Lawrence Gwynne, *Elements of Navigation, and a Treatise on Marine Fortification… for use of Children in the Royal Mathematical School*, 2 vols., seventh edition (1805); Hans, *New Trends in Education*, 39; Sullivan, 'The Royal Academy at Portsmouth 1729–1806', 319.
[21] J. Smyth, *Sandhurst: The History of the Royal Military Academy, Woolwich, the Royal Military College, Sandhurst, and the Royal Military Academy, 1741-1961* (London, 1961); O. Bruneau, 'The teaching of mathematics at the Royal Military Academy: evolution in continuity', *Philosophia Scientiæ*, 24 (2020), 137-58.
[22] L. Lochée, *An Essay on Military Education* (London, 1773); Hans, *New Trends in Education*, 103-5.
[23] B. Worster, *A Compendious and Methodical Account of the Principles of Natural Philosophy* (London, 1722); Watson, *Beginnings of the Teaching of Modern Subjects*, 251-3.
[24] Stewart and McCann, *Educational Innovators*, 15.
[25] B. Donn, *A New Introduction to the Mathematics*, second edition, 2 vols., (London, 1758), *The Schoolmaster's Repository…Designed for the Use of Schools* (London, 1764), *Epitome of Natural and Experimental Philosophy Including Geography and the Use of the Globes…designed for the Use of Schools* (London, 1769), *The British Mariner's Assistant* (London, 1774).
[26] F. B. Sullivan, 'The naval schoolmaster during the eighteenth century and the early nineteenth century', *Mariner's Mirror*, 62 (1976), 311-326.
[27] Marshall and Williams, *Great Map of Mankind*, 7-44, 45-63.
[28] Daniel Defoe, *Robinson Crusoe* (London; Joseph Mawman, 1815).
[29] J. Seally, *A Complete Geographical Dictionary, or Universal Gazetteer of Ancient and Modern Geography*, 2 vols., (London, 1787); Hans, *New Trends on Education*, 108-9.
[30] J. B. Florian, *An Essay on an Analytical Course of Studies* (1796); Hans, *New Trends in Education*, 79-81.
[31] E. Gibbon, *The History of the Decline and Fall of the Roman Empire*, 6 vols., (London, 1776-).
[32] Watson, *Beginning of Teaching Modern Subjects*, 105-10
[33] *Buffon's Natural History Abridged*, 2 vols., (London, 1792); O. Goldsmith, *A History of the Earth and Animated Nature*, 4 vols., (York, 1804).
Watson, *Beginning of the Teaching of Modern Subjects*, 110-11.
[34] P. Heylyn, *Cosmographie…Containing the Chorography and History of the Whole World* (1657) quoted in Watson, *Beginnings of the Teaching of Modern Subjects*, 125-8.
[35] F. Bacon, *The Advancement of Learning* (1605) in *The Works of Francis Bacon*, 10 vols., (London, 1824), vol. 1, p. 71.
[36] C. Hoole, *New Discovery of the Old Art of Teaching School* (1660) quoted in Watson, *Beginnings of the Teaching Modern Subjects*, 104-5.

[37] P. Elliott and S. Daniels, ‘‘No study so agreeable to the youthful mind’: geographical education in the Georgian grammar school’, *History of Education*, (2008), 1-18.
[38] P. Riden, *A History of Chesterfield Grammar School* (Chesterfield, 2017), 48-117; E. Darwin, letter to W. Burrow 11 December 1750 in D. King-Hele ed., *The Collected Letters of Erasmus Darwin* (Cambridge, 2007), 17-19.
[39] W. Gilpin, *Memoirs of Dr. Richard Gilpin…Together with An Account of the Author by Himself* (1801), edited by W. Jackson (London and Carlisle, 1879), 124-8; Stewart and McCann, *Educational Innovators*, 3-13.
[40] C. Wellbeloved, *Memoirs of the Life and Writings of the late Rev. W. Wood FLS* (London, 1809), 79-91, 98-103; R. Watts, *Gender, Power and the Unitarians in England, 1760-1860* (London, 1998), 48-8.
[41] Watts, *Gender, Power and the Unitarians*, 48-9.
[42] D. Williams, *Lectures on Education*, 3 vols., (London, 1789), vol 2, pp. 121-4, 133-40; McCann, *Educational Innovators*, 37-52.
[43] Williams, *Lectures on Education*, vol. 2, pp. 316-7, vol. 3, pp. 11-12, 22-25, 26-32, 28-32, 35; McCann, *Educational Innovators*, 48-; B. Simon, *The Two Nations and the Educational Structure, 1780-1870* (London, 1976), 38-46.
[44] S. Daniels, ‘’Outline maps of knowledge’: John Aikin’s Geographical imagination’, in F. James and I. Inkster eds., *Religious Dissent and the Aikin-Barbauld Circle, 1740-1860* (Cambridge, 2011).
[45] M. Bryan, *A Compendious System of Astronomy, in a Course of Familiar Lectures…,* second edition (London, 1797); M. Bryan, *Lectures on Natural Philosophy* (London, 1806); *Hope Deferred: Female Education*, 140-1; Hans, *New Trends in Education*, 203-4.
[46] J. B. Florian-Jolly, *Elementary Course of the Sciences* (1796), *Course of the Sciences and Philosophy* (1806); Hans, *New Trends in Education*, 79-81, 204-5.
[47] Watson, *Beginnings of Teaching Modern Subjects*, 111-13.
[48] P. Elliott and S. Daniels, ‘Pestalozzi, Fellenberg and British nineteenth-century geographical education’, *Journal of Historical Geography*, 32 (2006) 752-774.
[49] P. Elliott and S. Daniels, ‘Pestalozzianism, natural history and scientific education in nineteenth-century England: The Pestalozzian institution at Worksop, Nottinghamshire’, *History of Education*, 34 (2005), 295-313.
[50] P. Elliott, ‘Improvement, always and everywhere’: William George Spencer (1790-1866) and mathematical, geographical and scientific education in nineteenth-century England, *History of Education*, 33 (2004), 391-417.