THE MATHEMATICAL CURRICULUM AND PEDAGOGY IN ENGLAND 1780 - 1900: SOCIAL AND CULTURAL ORIGINS.

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1. The Influences on Education in England in the late Eighteenth Century.

The debates of the seventeenth century scientific revolution had produced significant changes in the popular views about the place of man in the physical universe, and the nature of that universe itself. In the next century, the views of English philosophers like Locke, Hume, Mill and Bentham, with their theories about the nature of man, of society, and of our acquisition of knowledge began to have some far-reaching influences on political and educational ideas in the latter part of the eighteenth century.

With the growth of the population of England from six million in 1750 to nine million in 1800, and with the great change from urban to industrial communities, and the hopes that industry would improve the conditions of life, the philosophy of utilitarianism was developed in the belief that society should seek to obtain and provide the "greatest good for the greatest number". At the same time, "laissez- faire" economics was promoted, with the purpose of regulating society by allowing the interplay of free forces in economics and society and monitoring their effects with minimal legislative interference. These benefits and forces, it was assumed, would be controlled by educated people making the right judgements about moral, political, and economic issues.

This belief that education was the real key to the improvement of the human condition was very strong. Philosophers emphasised human perfectibility; the idea that man is born without knowledge and becomes what education makes him, and that with the growth of knowledge and better education he is continually improving. Thus, education could do everything in influencing human beliefs, attitudes, morals and conduct. In fact, Locke's views on education were generally accepted by the "philosophes" of the enlightenment, and they appear to have had an influence on early French revolutionary politics from about 1790.

During this period, from the late 1700s to about 1850, we see a gradual development of the professionalisation and institutionalisation of mathematics teaching. Set against the considerable changes in social organisation and the economic development of the time, the kind of mathematics, the people who taught it, and the places where it was taught all underwent significant changes. One of my themes is that the isolation from industrial growth and technical improvement of the universities with their classical traditions was maintained and even increased, and the need for the practical applications of science and mathematics was answered by other sources and other institutions. In very broad terms, the division between the old universities and the other institutions where mathematics was taught was closely linked to the class system, and the established English intellectual and social attitude of the time. The industrial needs which brought about the social and institutional changes in the late eighteenth and early nineteenth century are the origin of the social and educational divisions still to be found in the English educational system.

2. The Schools.

In England at this time there was no state organised education. A few grammar schools existed, some of them founded as far back as the fourteenth century, where sons of the lesser

noblemen and landowners learnt the classics. Since these schools had been founded by Royal Charter, their curriculum could not easily be changed, and few taught any mathematics; perhaps the first two books of Euclid, and some simple arithmetic.

Any other kind of education was locally organised, usually by well-meaning clergymen and public benefactors. These were called Dame Schools or Charity Schools. In these schools it was possible to learn reading, writing, ciphering (elementary arithmetic), and the catechism. Some clergymen took private pupils, possibly to earn some extra income, than from any purely educational motive and this tradition continued well into the next century.

By the late 1780s Sunday Schools were established for the poor, in order "to educate them in the principles of religion and the duties of their state in life." Not surprisingly however, the schools had the opposite effect that the establishment required. Due to the Sunday School teachers' concern for the health and welfare of their pupils, the "poor" were actually prepared through this rudimentary education for various public duties, and the teachers unwittingly "created thought in the unthinking masses".

Not until the 1830s do we begin to see the development of the English Public School system (ecoles privees) which prepared boys from middle and upper class families for the universities and their eventual careers in the church, the civil service or the army. The amount of mathematics and science taught in these schools was very variable, since the teachers trained in the old universities had very strong classical traditions, and schools like Eton, Harrow and Rugby did not appoint mathematics masters until the 1830s when they began to be challenged by some of the newly founded schools.

3. Non-Conformist Middle Class Education and the Private Schools

From 1766 a group of gentlemen held informal meetings in Birmingham every month to discuss and experiment in the new ideas of natural philosophy. This became known as the "Lunar Society". Among its early members were Boulton, Watt, Priestly, Galton and Erasmus Darwin (the grandfather of Charles Darwin). This was probably the best known of a number of "Literary and Philosophical Societies that were founded about this time. The new middle class who became members of these societies were often forward looking individualists, scientists or innovators with many interests in the practical applications of the new ideas of natural philosophy.

Later, more liberal interests developed, and they encouraged not only the advancement of science and technology, but also social and political education. To these ends, the new middle class founded a number of private academies whose role was to educate the sons of the Non-conformists (Wesleyan and Methodist) for their place as leaders of the new industrial developments.

The Private or "Dissenting" Academies were born in the industrial midlands of England, (cities like Manchester, Sheffield, Birmingham and Liverpool), and were the places where Non-conformists could go to be educated since Oxford and Cambridge would only admit those who were prepared to swear an oath of allegiange to the King as head of the Church of England. In any case the curriculum of the universities of the time was of no interest to young industrialists.

The earliest of these Private Academies was Warrington Academy, founded in 1757. Unlike the universities, the curriculum was intended to prepare the students for life in an industrialised society, and so the subjects that were taught had obvious practical applications.

Another famous college, Manchester College of Arts and Sciences was founded in 1783 by members of the Manchester Literary and Philosophical Society. This institution became later Owens College in 1853, and then finally in the 1890s, Manchester University.

The College of Arts and Sciences taught sciences and practical arts most relevant to local industry. Its syllabus contained classical languages, grammar and rhetoric, mathematics (including trigonometry), mechanics, natural philosophy, (including astronomy and chemistry) English composition, French, commercial and economic geography, history, politics, writing, drawing, book-keeping and shorthand.

Subjects like these became the standard curriculum, and most of the important cities of this time developed their independent educational institutions in this manner. There was a great demand for applied science in many areas, and the "mixed mathematics" (that is, practical geometry, measurement, arithmetic and sometimes fluxions) (Nicholson 1823, Cook 1981) became a central subject in the curriculum.

The situation becomes even more complex when we consider that many other private schools had been founded to cater for the special needs of business and industry. Schools of navigation had grown up in the major ports, and military academies provided an education for the entrants to the army. Probably the best known of these, was Woolwich academy, where Bonnycastle and Hutton taught, and where the syllabus in 1800 consisted of arithmetic: fractions, roots and powers, proportion, interest, permutations and combinations; algebra: arithmetic and geometric progressions, logarithms, simple, quadratic and cubic equations; geometry: plane trigonometry, mensuration, surveying, conic sections; dynamics, projectiles, hydrostatics, hydraulics and fluxions. (Howson 1982 p.68)

4. Self-Education of the workers.

From the 1790s onwards artisans, small tradesmen and labourers began to study and learn by direct participation in political struggles; by reading the radical press and attending lectures of agitators and propagandists. Organisations which supported this activity were called the "corresponding societies", and while on the one hand they were often the centres for political agitation, on the other they provided organised and disciplined opportunities for study for ordinary working people.

In contrast to the aims of the Sunday Schools, their aims were (i) to inform people of the reasons for their condition and the state of society and industry; and (ii) to encourage the progress of human reason and place instruction within the reach of every citizen.

The teaching methods encouraged self-confidence, clear thinking and the capacity for self expression, and the organisers realised the importance of combining systematic education with mass political agitation. Books and newssheets were shared: an individual would be asked to take a book home, read a passage and prepare to talk about it to the group at the next meeting. The book would then be passed on to someone else and the process repeated. Many subjects, including elementary mathematics (which was principally arithmetic) were learnt in this way.

As a result of this self-education movement which developed from the rank and file of workers, there came men able to master and comprehend some of the most advanced political thinking of the time, who could be informed, and critical leaders of the new working class movement. This was recognised as a threat by the establishment (the ruling aristocracy, the Church and the upper middle classes), so that in 1799 an Act of Parliament was passed and in section 15 we find that one of the purposes of the Act is:

"..for the more effectual suppression of societies for seditious purposes.."

5. The English Radicals: Science as a Foundation for Education.

In 1798 Tom Paine published "The Rights of Man", an attack on the established social order and what he saw was its exploitation of the poor and the working classes. In that year also we have Thomas Edgworth, a well known English Educator criticising the methods of rote learning and the narrowness of the grammar school syllabus. The radicals saw the Church as

the main obstacle to political reform in its indoctrination of the people which reinforced the strong social stratification and kept people "in their place". The radicals began to replace this religious indoctrination of children with a form of rational education through the Sunday Schools. Further ideas were spread by the radical press with journal names like "Black Dwarf" and "The Cap of Liberty", which was clearly a reference to political changes in France. By 1817 there were clear popular demands for a rational secular education for all as the necessary foundation for good government; an essential part of radical reform.

Paine had demanded the teaching of science which was directly applicable, instead of dead languages which had no use, but more importantly science was regarded as the cornerstone of a rationalist philosophy. While it was politically safe to be a rationalist philosopher if you were a member of the upper classes (it was regarded as an intellectual fashion, without any threat to the established structure of society), rationalism in the market place was seen as a serious threat.

All this activity was of great concern to the establishment, and in 1817 a House of Lords Secret Committee reported on the unprecedented circulation of "publications of the most seditious and inflammatory nature, marked with a peculiar character of irreligion and blasphemy, and tending not only to overturn the existing form of government and order of society, but to root out those principles upon which alone any government or any society can be supported."

To prevent the circulation of such newspapers, the Stamp Act was made law, which required the registration and taxing of all newspapers and journals. This was immediately regarded as a tax on popular knowledge. As a result, the radical newspapers were forced to carry on their crusade underground.

In 1821 Richard Carlisle published his "Address to Men of Science". It was inspired by Tom Paine's "Age of Reason", and Carlisle was sent to prison for his dangerous radical views. The "Address" appeals to scientists (especially chemists and astronomers) to make their philosophical implications known. If it is true that "matter cannot be created or destroyed", then creation is an inappropriate word to use, and so the study of Astronomy exposes the futility of religious cosmologies.

The call to establish a new kind of education was very strong and the radicals and rationalists demanded that religion, (by which they meant the learning of the catechism and the maintenance of the strict social order), should be abandoned and that people should study scientific subjects.

They demanded a curriculum which contained reading, writing, the use of figures (i.e. arithmetic, geometry, algebra, mechanics), elements of astronomy, geography, natural history and chemistry so that children may "at an early period of life form correct notions of organised and inert matter, instead of torturing their minds with metaphysical and incomprehensible dogmas about religion" They believed that science was the key to knowledge and freedom, and that these subjects were best studied by observation and experiment. They put forward a materialist psychology, and demanded free discussion and example instead of repetition and superstition.

6. The Education of Girls

Girls were hardly provided for at all. They sometimes appear as pupils in the elementary schools, but are generally not regarded as worth educating in anything more than the most elementary skills. However, those girls who were lucky enough to have brothers, and whose parents employed private tutors, were often taught alongside their brothers, and some profited from this opportunity.

The "Ladies Diary" which was published from 1704 to 1841 was noted for the

mathematical problems it contained. Many women contributed to the solution of these problems, and we assume that many of them would have been taught by private tutors. However, many women published under male or Latin pseudonyms, perhaps feeling that they had a better chance of being heard if they disguised their femininity. From about the 1860s we find a growing movement for the elimination of sex differences in education, particularly in mathematics and science.

Opportunities for further education were severely limited. There was no admission of women to the colleges of Oxford and Cambridge before the beginning of this century, and the private academies were considered to be no place for girls. The Victorian attitude to the mental capabilities of women, and their low social status, together ensured that there were very few opportunities. However, this was to change slowly with the publication of the "Educational Times" in 1847, where subjects like the importance of women in society, and the qualities of women's minds were intelligently discussed and freely promoted. The College of Preceptors, founded in 1846 played a major role in the support of women, and as the teacher training institutions developed in the latter part of the nineteenth century, young women took advantage of this situation to educate themselves and to raise their social status.

7. The Mechanics Institutes (c. 1820 - 1860)

Most of the Literary and Philosophical Societies either supported or evolved into the Mechanics Institutes, which were founded in many English industrial cities and initially became the focus for the growing working class movement for self education. The Mechanics Institutes (Inkester 1975, Royle, 1971) were founded principally to provide some elementary education to the semi-literate workers, they introduced science, literature and the arts; deliberately excluded politics and religion, and provided lectures, evening and day classes, and libraries. There was a substantial demand for reading; the reading of scientific (and clandestinely also political) texts was first of all organised on a self-help basis where the books were passed from one to another, and people took it in turn to hold meetings in their house. Those who had the necessary skills taught others to read and led meetings where workers in turn read, interpreted and discussed the ideas in the texts with the members of the group. The Mechanics Institutes provided a focus for this activity with the establishment of the reading rooms and loan systems.

Many of the public lectures and demonstrations were quite spectacular and generated great interest in various subjects showing ordinary people the wonders of science.

The working people became aware that science would be a determinant of general technical change and the quality of living in the future. The lectures however, were seen to be part of a total learning process where special classes and personal reading in the particular subject area were also important. The Prospectus of the Sheffield Mechanics Institute states; "The object of this Institute is to supply, at a cheap rate, to the classes of the community, those advantages of instruction, in the various branches of Science and Art which are of practical application to their diversified avocations and pursuits."

However, a later statement clearly points out that "controversial subjects" like religion and politics were not to be studied in the Institutes since they were intended to be ".a voluntary association of a portion of the humbler classes of the town or locality assisted by a few of the leading and wealthy inhabitants, to raise, by means of small periodical contributions, a fund to be expended in the instruction of the members in science, literature and the arts to the exclusion of controversial divinity, party politics, and subjects of local dispute, by means of a library of circulation, lectures, evening or day classes, and a reading room."

The curriculum structure and content was largely based upon what was judged to be "useful" to workers, and many lectures were related to practical applications and the consideration of local engineering and manufacturing problems. There was a clear recognition that any advanced learning depended on the basic skills of reading, writing and arithmetic. Also, the concept of "progressive instruction" was established thus guaranteeing some

continuity of instruction for the workers, and employment for the lecturers. Advanced classes were given in a selection of subjects like Grammar, French, Latin; Science, Chemistry, Electricity; Mixed Mathematics, Algebra and Mensuration. The demand for these varied, and further study depended on the level of acquisition of the basic skills. For example, at Manchester in 1856, more people studied the "three R's" (reading, writing and arithmetic), than all the other subjects combined.

Provision for science also meant that collections of apparatus and specimens began to be built up, and whereas before, the professional lecturer often supplied his own apparatus, the Institute now employed the services of local instrument makers. Another aspect of this institutionalisation of learning is that the lecturers themselves, instead of moving from place to place to give their lectures in village halls to anyone who would listen (and who could afford to pay), now began to settle into posts in the new institutions where they had much greater chances to establish courses, to develop curricula and write texts.

At the same time, workers deprived of their jobs saw science and technical innovations as a means of cutting wages and producing unemployment, and parallel to the scientific interest, considerable political activity continued outside these institutions. Since the demand for political education and the discussion of religious issues was not met within the Mechanics Institutes, the clientele of the Institutes began slowly to be made up more and more of people from the "lower middle classes", whose social and employment situation was generally more stable than the "labouring classes". In this way the Institute's programme was often rejected by the class for whom it was intended. They became places where the middle classes heard lectures on "middle class subjects", and where young men of low social status but relatively secure economic status could obtain an elementary education.

8. Changes in the Universities

Although Robert Woodhouse had published his "Principles of Analytical Calculation" which introduced the Leibnizian differential notation to English mathematicians in 1803, it had very little effect. In fact, in complete contrast, in 1801, John Colson had published an English translation of the well-known but rather out-dated "Instituzioni Analytiche" of Agnesi originally published in 1748, apparently ignoring all the texts of the French mathematicians of the 1790s. The turning point for the revision of university mathematics in England is generally taken to be the formation of the Analytical Society at Cambridge in 1813. The translation into English of the 1802 edition of Lacroix using the Leibniz notation, and the introduction of the Lagrangian approach to the calculus was a significant event. The central figure in the reform was George Peacock, who during his appointments as moderator of the Cambridge examinations, ensured that the differential notation was used in the examination questions. The first entirely English text book on the calculus was Lardner (1825). From then on, through the early nineteenth century, we have a process where English university mathematics was catching up with the standard of colleagues on the continent so that by the 1860s, we have mathematicians of the calibre of Cayley, Sylvester, Hamilton, Hirst and Clifford influential positions in the universities.

In 1826 the Liberal politicians finally broke the monopoly of Oxford and Cambridge, and University College London was founded. Its statutes avoided any religious affiliation, and the principal figure involved was Jeremy Bentham, the humanist philosopher and reformer.

In 1828 Augustus De Morgan was appointed the first professor of mathematics. While perhaps not regarded as a first rank mathematician, he was certainly a thoughtful, idealistic and energetic educator whose text books and pedagogical writings show a deep concern for the problems of learning and teaching mathematics. Also in 1828, after considerable agitation to provide a religious foundation in London, another university college, King's College London was founded.

De Morgan's pedagogical texts (De Morgan 1831) had wide circulation through journals

like the "Penny Cyclopaedia", which was the main publication of the "Society for the Diffusion of Useful Knowledge" (SDUK), and which serialised his "Differential and Integral Calculus" in some twenty five weekly parts. The calculus was later published as a single volume in 1842. A number of other writers like Dionysius Lardner (Lardner 1825) and Olinthus Gregory also contributed to the popularising of scientific and mathematical knowledge in this way, and Isaac Todhunter's book (Todhunter 1852) became the standard calculus text for the rest of the century.

It was still the case however, that the university of Cambridge dominated the educational system, and in 1850 the fact that Cambridge required a knowledge of Euclid for its entrance examinations, made the other universities follow suit. So, while the mathematics within the universities was bringing itself into the same league as that of the continent of Europe, the changes in the schools were almost non existent.

In 1851, at the time of the Great Exhibition, the Royal College of Science, and the Royal School of Mines were founded under the patronage of Prince Albert. These later became Imperial College, and as the names imply, applied mathematics featured highly in the curriculum.

Towards the end of the nineteenth century we see a strong movement in the colleges outside the universities where advocates of practical mathematics were designing new courses and writing new textbooks. These authors were often the new professors of science and engineering in the universities who were wanting to reform the curriculum and the teaching methodology in the schools and colleges because they considered that the mathematics education that students had undergone was inadequate for the new university courses. Prominent among these was Perry (Perry 1899), a significant figure in the reform of mathematics teaching at this time.

A wider discussion of the development of the mathematics curriculum and its pedagogy in the latter part of the century can be found in Price (Price 1983). However, the full story of the earlier part of the century and the role of institutions like the College of Preceptors, journals like the Educational Times, and the individuals behind them has yet to be told. I am indebted to Janet Burt, John Fauvel, Mike Price and many other colleagues in the British Society for the History of Mathematics for their interesting conversations and the opportunities we have to discuss some of these issues at our meetings.

Appendix 1

Select Chronology of Educators and Educational events.

1741 Royal Military Academy Woolwich Founded Bonnycastle, Barlow, Gregory, Hutton, Thos. Simpson, J.J. Sylvester.

1757 Warrington Academy founded.

1766 First meetings of the Lunar Society.

1783-9 Thomas Day. The History of Stanford and Merton. Popular childrens book containing radical educational and social ideas. 50 editions up to the 1890s.

1783 Manchester College of Science and Arts.

1798 R.L. and M. Edgworth. Practical Education 2 vols. Criticism of rote learning and narrow grammar school curriculum.

1799 Act of Parliament section 15 "..for the more effectual suppression of societies for seditious purposes..".

1799 Cambridge final examination requires the first book of Euclid, Arithmetic, Vulgar and decimal fractions and Simple and Quadratic Equations.

1800 Woolwich Academy mathematics syllabus: Arithmetic (including fractions, roots, powers, proportion, interest, permutations and combinations), arithmetical and geometrical progressions, logarithms, simple, quadratic and cubic equations),geometry, plane trigonometry, mensuration,surveying, conic sections, dynamics, projectiles, hydrostatics, hydraulics and fluxions.

1813 Analytical Society at Cambridge Babbage, Herschel, Peacock, Whewell.

1815 Formation of the "Hampden Clubs"

1817 House of Lords Secret Committee

1819 James Mill. "Education" in Supplement to Encyclopaedia Britannica London 1819.

1821 Richard Carlisle - "Address to Men of Science"

1826 Liberal Politicians break the monopoly of Oxford and Cambridge: University College London Founded ("that heathen place")

1826 Society for the Diffusion of Useful Knowledge (SDUK)

1828 De Morgan. Appointed first Professor of Mathematics at University College London.Inaugural lecture" On the Study of Mathematics".

1828 Kings College London Founded

1831 British Association for the Advancement of Science

1833 Factory Act. Employers must release children for 2 hours school each day

1836 William Whewell: "Thoughts on the Study of Mathematics as Part of a Liberal Education."

1837 Compulsory Registration of Births.

1839 Privvy Council Committee on Education.

1840's University Examination systems established Oxford, Cambridge and London adopt Euclid as a standard text for elementary geometry.

1843 Lord Shaftesbury.Speech on manufacturing industries and the lack of provision of education for the working class.

1844 Factory Act.Schooling increased to 3 hours each day.

1845 Whewell, J. "Of a Liberal Education"

1846 College of Preceptors founded

1846 Kay, Joseph."The Education of the Poor in England and Europe"

1847 Educational Times published

1850 Public Libraries Act.Local tax to subsidise library provision.

1852 The Great Exhibition of Sciences and Arts.

1853 Foundation of the Government Department of Science and Arts

1855 Newspaper Tax abolished

1860 By this time mathematics as "arithmetic, algebra and geometry" is fairly well established as part of a "liberal education" for boys.

1861 to 1866 Darwin's voyage in the "Beagle"

1861 Spencer, H. Education, Intellectual, Moral and Physical. Science is the most valuable kind of knowledge.

1861 Clarendon Commission appointed to Inquire into the State of Popular Education in England

1862 Kay-Shuttleworth, James: "Four Periods of Public Education."

1865 London Mathematical Society

1868 Taunton Commission appointed to report on and advise the government of the state of schooling.

1868 Trades Union Congress founded

1869 Report of the First General Meeting of the National Education League

1870 First Education Act establishes public elementary education.

1871 Foundation of the Association for the Improvement of Geometrical Teaching (AIGT). Later to become the Mathematical Association.

1870's Department of Science and Art examinations encourage the use of drawing instruments and the use of practical geometry.

1886 Royal Commission appointed to enquire into the working of the Elementary Education Acts

1899 Perry's lectures "On practical mathematics to working men".

Appendix 2

Types of Activity in Nineteenth century Mathematics Teaching.

1. Independent practitioners.
These were the Instrument Makers, Cartographers, Surveyors, etc. they used, and were able to communicate a fairly high level of specialised mathematics as applied arithmetic, geometry, trigonometry, algebra and in some cases fluxions.

2. Apprentice Masters.
At all levels of industry where established trades were being used, or were finding new applications, for example where the barrels originally made by the coopers for beer were used to transport pottery, or where new skills were being developed, as in the conversion and use of the wood lathe for metal work. Generally elementary and specialised calculations.

3. Private Tutors.
These were sometimes "practitioners", but more usually they were employed exclusively for the education of one family, and lived in that family house. This was the preferred course for the "sons of Gentleman", and if this was too expensive, their sons were put out to lodge with the local vicar who might supplement his income by educating two or three boys.The private tutors who were employed by families often taught the girls the same subjects as the boys, and thus a number of girls learnt arithmetic and Euclid.During this time the tradition of the English country clergy as tutors became established. They had been educated at Oxford or Cambridge, and many of them made considerable contributions to English mathematics particularly in the latter part of the nineteenth century.

4. Grammar Schools.
Originally founded by Royal Charter, and formerly providing for the sons of the "gentry", these often had a long established tradition with a strong classical emphasis. If any mathematics was taught, it was some arithmetic, and some of the first two books of Euclid. Their charter usually prohibited any variation in their curriculum, which had ben set up a considerable time ago.

5. Specialised Institutions.
Schools of Navigation were run by the Navy or the Trading Companies (though much of this instruction was done at sea), while some Grammar and Public Schools in the great Ports taught mathematics and navigation. Military Academies like Woolwich taught various aspects of applicable mathematics, and Mechanics Institutes were the "evening institutes" providing basic education and practical scientific knowledge to the working man. Many of these evolved, along with the Private or "Dissenting".

Academies into the Technical Institutions of the late nineteenth and early twentieth century..

6. Private or Dissenting Academies.
Originally establish to educate the Non-Conformist (Calvinist, Wesleyan and other Protestant) ministers, they quickly became the most important institutions for educational change. This is where the industrialists of the Midlands sent their sons, and as forward-thinking and liberal minded individuals they had an influence on the curriculum. Their basic philosophy was that the advancement of knowledge depends upon its application, and that learning should be put to social use. Many of them later evolved into Mechanics Institutes.

7. Public Schools.
From the middle to latter part of the nineteenth century there was a gradual development of these private institutions by more liberal minded (upper class, Church of England) individuals, who were on the whole more aware of the needs of society, and who attempted to bring more science and mathematics into the curriculum for pupils from upper middle class and aristocratic backgrounds.

8. Popularisers and Writers.
Many of these taught mathematics in the Academies, Colleges, Institutes and in the new Universities. A few important names are Olinthus Gregory, Dionysius Lardner, Thomas Tate, Augustus de Morgan and Mary Boole. Their subjects and motivations varied considerably. Textbooks were written as handbooks for schoolmasters and teachers in the Academies or Institutes, or as special texts and sets of questions to help pass examinations or as serialisations of practical and applicable mathematics for popular consumption. Quite often a writer would be promoting particular educational principles, or a particular philosophy of mathematics, or of mathematics teaching.

9. Societies.
A large number of "Literary and Philosophical Societies" flourished in the early part of the century. Most evolved into institutions which became the Technical Institutes in the latter part of the century. For example, the Manchester Lit. and Phil. Society is regarded as the ancestor of Manchester University. The "Society for the Diffusion of Useful Knowledge" (SDUK) was

founded by liberal middle class teachers, lawyers, clergy and members of parliament to provide cheap mass education through a number of serial publications. The "Penny Cyclopaedia" was the principal serial. For example, De Morgan's Differential and Integral Calculus was serialised in 25 parts.
Specialist societies arose like the Cambridge Philosophical Society (1824), and the London Mathematical Society (1865)

10. Publications.
There were many newspapers, serials, journals, encyclopaedias, all carried articles on mathematics of varying quality. Some of the best known are The Ladies Diary, Transactions of the Cambridge Philosophical Society, Nature, Transactions of the Manchester Literary and Philosophical Society, and the Penny Cyclopaedia.

11. Teacher Training Institutions.
These gradually evolved as a means of training Primary teachers and writers like the Edgworths, Erasmus Darwin and Joseph Priestly justified mathematics by its "utility" and included it in the basic school curriculum. Later, specialist teachers organisations like the Association for the Improvement of Geometrical Teaching (AIGT 1871) were organised and protested against the traditional university based curricula.

12. Government Encouraged Institutions and Departments.
These were set up after the Great Exhibition of 1851 to encourage the greater exploitation of ideas in industry. The Department of Science and Arts was the first official government body, and The Royal College of Science (now Imperial College) and the Royal School of Mines were created. Government also sponsored grants for individuals and industries where mathematics was applied.

13 Examinations
Final examinations at Oxford and Cambridge became written tests in the eighteenth century. By about 1830 the universities of London, Oxford and Cambridge all required examinations as a means of establishing the "basic knowledge" required for a university course. However, the standards were very variable. Entrance examinations for the universities began in about 1850 when Cambridge decided that a knowledge of Euclid was necessary for a university course in mathematics.

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