GEORGE GHEVARUGHESE JOSEPH

Foundations of Eurocentrism in mathematics

There exists a widespread Eurocentric bias in the production, dissemination and evaluation of scientific knowledge. And this is in part a result of the way many perceive the development of science over the ages. For many Third World societies, still in the grip of an intellectual dependence promoted by European dominance during the past two or three centuries, the indigenous scientific base which may have been innovative and self-sufficient during precolonial times is neglected or often treated with a contempt that it does not deserve. An understanding of the dynamics of precolonial science and technology in these societies and an identification of the nature of the base on which the superstructure rested are essential in formulating a strategy of meaningful adaptation of the indigenous forms that remain to present-day scientific and technological requirements.

Now an important area of concern for anti-racists is the manner in which European scholarship has represented the past and potentialities of non-white societies with respect to their achievement and capabilities in promoting science and technology. The progress of Europe and its cultural dependencies* during the last 400 years is perceived by many as inextricably – and even causally – linked with the rapid growth of

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* The term 'cultural dependencies' is used here to describe those countries – notably the United States, Canada, Australia and New Zealand – which are mainly inhabited by populations of European origin and share similar historical and cultural roots as Europe. For the sake of brevity, the term 'Europe' is used hereafter to include these areas as well.

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science and technology. So that in the minds of many, scientific progress becomes a uniquely European phenomenon, to be emulated only by following the European path of social and scientific development.

Such a misrepresentation of the history and cultures of societies outside the European tradition raises a number of issues which are worth exploring. First, there are certain implications for the nature of the relationship between knowledge and power which was indicated at the beginning of this article. Second, there is the issue of who 'makes' science and technology. In a material and non-elitist sense, people from all continents have contributed to the growth of knowledge in general and of science in particular. Third, if one is imprisoned within the ethnocentricity of a particular place/time location, then non-European reality may only impinge marginally either as an unchanging residual experience to be contrasted with the dynamism and creativity of Europe, or as a rationale for the creation of disciplines congealed in subjects such as development studies, anthropology, Orientalism, Sinology and Indology. These subjects then serve as the basis from which theories of social development and history can be developed.

The shaky foundations of these 'adjunct' disciplines are being increasingly exposed by scholars, mainly from those countries which provide the 'raw materials' of these disciplines. In a recent contribution to *Race & Class*,[1] Edward Said points to a number of examples of 'subversive' analyses, inspired by similar impulses as his seminal anti-Orientalism critique,[2] which are aimed at nothing less than the destruction of the existing Eurocentric paradigmatic norms. For example, the growing movement towards promoting a form of indigenous anthropology which sees its primary task as questioning, redefining and, if necessary, rejecting particular concepts which grew out of colonial experience in western anthropology is well examined in Fahim.[3] In a similar vein, I propose to show that the standard treatment of the history of non-European mathematics is a product of a historiographical bias (conscious or otherwise) in the selection and interpretation of facts which, as a consequence, results in ignoring, devaluing or distorting contributions arising outside European mathematical traditions.*

* A concise and meaningful definition of mathematics is virtually impossible. In the context of this article, the following aspects of the subject are particularly relevant. Mathematics can be looked at as an international language, with a particular kind of logical structure. It contains a body of knowledge relating to number and space. It prescribes a set of methods for obtaining conclusions about the physical world. And it is an intellectual activity using both intuition and imagination to arrive at proofs and conclusions which may carry a high sense of aesthetic satisfaction for the creator.

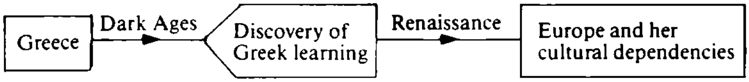
The historical development of mathematical knowledge

Most histories of mathematics which were to become standards for later work were written in the late nineteenth or early twentieth centuries. During that period two contrasting developments were taking place which would have an impact both on the content and the balance of the books produced on both sides of the Atlantic. On the one hand, exciting discoveries of ancient mathematics written on papyri in Egypt and clay tablets in Mesopotamia, dating back to the second millenium BC, had pushed back the origins of written mathematical records by at least 1,500 years.

But a far stronger counter-influence was the political climate of the day, when the same period saw the culmination of European domination in the shape of a 'Scramble for Africa' and the final subjugation of Asia by imperialist powers. As an adjunct to imperial domination arose the ideology of racism and white superiority which spread over a wide range of social and economic activities, including the writing of histories of science. These histories emphasised the unique role of Europe as providing the soil and spirit for scientific discovery. The contributions of the colonised were ignored or devalued as part of the rationale for subjugation and dominance. And the developments in mathematics before the Greeks – notably in Egypt and Mesopotamia – suffered a similar fate, being dismissed as of little importance to the future of the subject.

Figure 1 presents a 'classical' Eurocentric view of how mathematics developed over the ages. This development is seen as taking place in two areas separated by a period of inactivity lasting for a thousand years – Greece (from about 600 BC to 300 AD) and post-Renaissance Europe from the fifteenth century to the present day. The intervening period of inactivity constituted the 'Dark Ages' – a convenient label which was both an expression of post-Renaissance prejudices about its immediate past and of the intellectual self-confidence of those who saw themselves as the true inheritors of the 'Greek miracle' which was supposed to have sprung up spontaneously from the Ionian soil 2,000 years earlier.

Figure 1: *The 'classical' Eurocentric approach*



Two passages, one by a well-known historian of mathematics writing at the turn of the century and the second by a contemporary writer whose books are still widely referred to on both sides of the Atlantic, show how impervious is Eurocentric scholarship to new evidence and sources.

> The history of mathematics cannot with certainty be traced back to any school or period before that of the Ionian Greeks.[4]

> [Mathematics] finally secured a firm grip on life in the highly congenial soil of Greece and waxed strongly for a short period . . . With the decline of Greek civilisation, the plant remained dormant for a thousand years ... when the plant was transported to Europe proper and once more imbedded in fertile soil.[5]

The first statement is a fair summary of what was generally known at the turn of this century, except for the intriguing omission of early Indian mathematics contained in the *Sulbasutras* (c800-c500 BC), translated by Thibaut between 1874 and 1877, which were at least contemporaneous with the earliest known Greek mathematics. The second statement ignores a substantial body of research evidence pointing to significant development in mathematics in Mesopotamia, Egypt, China and pre-Columbian America. Mathematics is perceived as an exclusive product of white men and European civilisations. And that is the central message of the Eurocentric trajectory described in Figure 1.

But this comforting rationale for an imperialist/racist ideology of dominance became increasingly untenable for a number of reasons. First, there was the fulsome acknowledgment by the ancient Greeks themselves of the intellectual debt they owed to the Egyptians and Babylonians. There are scattered references from Plato (c380 BC) to Plutarch (c100 AD) to the early knowledge acquired from the Egyptians in various fields, including astronomy, mathematics and surveying, with a number of commentators considering the priests of Memphis as founders of science. Both Thales (cd 546 BC), the legendary founder of Greek mathematics, and Pythagoras (cd 500 BC), one of the earliest and greatest of Greek mathematicians, were reported to have travelled widely in Egypt and Babylonia and learnt much of their mathematics from these areas. Some sources even credit Pythagoras with having travelled as far as India in search of knowledge, which may explain some of the close parallels between Indian and Pythagorean philosophy and geometry.*

* These parallels are found in the following areas: (a) a belief in transmigration of souls; (b) the theory of five elements constituting matter; (c) the reasons for prohibiting consumption of beans; (d) the structure of the religio-philosophical character of the Pythagorean fraternity which shared certain similarities with Buddhist monasteries; and (e) the contents of the mystical speculations of the Pythagorean school which bears a remarkable resemblance to *Upanishads*. The statement of the Pythagorean theorem in geometry is found in *Sulbasutras* (the oldest extant documents containing Indian geometry). According to Greek tradition, Pythagoras, Thales, Empedocles, Anaxagoras, Democritus and others undertook journeys to the East to study philosophy and science. While it is far fetched to assume that all these individuals reached India, there is a strong historical possibility that some of them became aware of Indian thought and science through Persia.

A second reason why the trajectory described in Figure 1 is untenable arose from the findings of the combined efforts of archaeologists, translators and interpreters who unearthed evidence of a high level of mathematics practised in Mesopotamia and to a lesser extent in Egypt from the beginning of the second millenium BC, which provided further confirmation of Greek reports on the nature of such mathematics. In particular, the Babylonian mathematicians had invented a place value number system, understood (but not proved) the so-called Pythagorean theorem* and evolved an iterative method of solving quadratic equations which would only be improved upon in the sixteenth century AD.

Third, the significance of the Arab contribution to the development of European intellectual life could no longer be ignored. The course of European cultural history and the history of European thought are inseparably tied up with the achievement of Arab scholars during the Middle Ages (or the Dark Ages as they came to be known by post-Renaissance Europe) on account of their seminal contributions in mathematics, natural sciences, medicine and philosophy. In particular, we owe to the Arabs in the field of mathematics the bringing together of the technique of measurement, evolved from its Egyptian and Babylonian roots to its final form in the hands of Greeks and Alexandrians, with the remarkable instrument of computation (our number system), which originated in India, and finally supplementing these strands with a systematic and consistent language of calculation which came to be known by its Arabic name, algebra. A grudging acknowledgment of this debt by certain books contrasts sharply with a general neglect when it came to recognising other Arab contributions. **

Fourth, there was some recognition that in talking about the Greek contribution one should separate the classical period of Greek civilisation (i.e., from the sixth century to the third century BC) from the post-

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* The statement and demonstration of the so-called Pythagorean theorem is found in varying degrees of detail all over the world. A variety of evidence is at present available on the widespread practical use of the theorem among the Babylonians (c1800-1600 BC). The Chinese provided a proof of the theorem in their oldest extant mathematical text entitled *Chou Pei* (500 BC). As mentioned earlier, the *Sulbasutras* (c600-800 BC) contained the earliest known general proof of the theorem. It is also worth noting that even though the theorem is universally associated with the name of Pythagoras, there is no evidence that Pythagoras had either stated or proved the theorem. The earliest Greek proof, which is still to be found in school geometry texts, was given by Euclid (c300 BC).

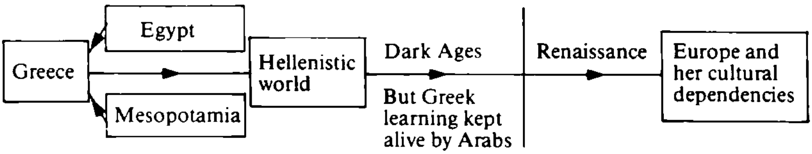
** The unacknowledged debt to Arab science includes: (a) an earlier description of pulmonary circulation of the blood by Ibn al-Nafis, usually attributed to Harvey; (b) the first known statement of the principle of the refraction of light by Ibn al-Haytham, usually attributed to Newton; (c) the first known statement of the law of gravity by al-Khazin, again attributed to Newton; (d) the first clear statement of the theory of evolution by Ibn Miskawayh, usually attributed to Darwin; and (e) the first explanation of the rationale underlying the 'scientific method' which is found in the works of Ibn Sina, Ibn al-Haytham and al-Biruni but usually credited to Bacon.

Alexandrian dynasties (i.e., from the third century BC to the third century AD). In early Eurocentric scholarship, the Greeks of the ancient world were perceived as ethnically homogeneous and originating from areas which were mainly within the geographical boundaries of present-day Greece. It was part of the Eurocentric mythology that from the mainland of Europe had emerged a group of people who had created out of virtually nothing the most impressive of all civilisations of ancient times. And from that civilisation had sprung not only the cherished institutions of the present-day western culture but also the mainspring of modern science and technology. The reality is, however, more complex and problematic.

Before the appearance of Alexander (356-323 BC), the term 'Greek' did encompass a number of independent city states, often at war with one another, but exhibiting close ethnic and cultural bonds, and above all sharing a common language – whose alphabet was borrowed from the Phoenicians of North Africa. The conquests of Alexander changed the situation dramatically, for at his death his Empire was divided among his generals who established separate dynasties. The two notable dynasties from the point of view of mathematics were the Ptolemaic dynasty of Egypt and the Selucid dynasty, which encompassed the earlier site of Mesopotamian civilisation. The most famous centre of learning and trade became Alexandria in Egypt, established in 332 BC and named after the conqueror. From its foundation, one of its most striking features was its cosmopolitanism – part Egyptian, part Greek with a liberal sprinkling of Jews, Persians and Phoenicians, and even attracting scholars and traders from as far away as India. A lively contact was maintained with the Selucid dynasty. It thus became the meeting-place for ideas and different traditions, and over the period the character of Greek mathematics changed mainly as a result of the continuing cross-fertilisation between different mathematical traditions, notably the algebraic and empirical traditions of Babylonia and Egypt interacting with the geometric and anti-empirical traditions of classical Greece. And from this mixture came some of the greatest mathematicians of antiquity – notably Euclid, Archimedes, Apollonius and Diophantus. It is, therefore, misleading to speak of Alexandrian mathematics as Greek, except in so far as the term indicates that Greek cultural traditions served as the main inspiration and the Greek language as the medium of instruction and writing in Alexandria. In that sense, the use of the term 'Greek' is closely analogous to the use of the term 'Arab' to describe a civilisation which encompassed a number of ethnic and religious groups, but all of whom were imbued with the Arab culture and language.

Figure 2 describes a 'modified' Eurocentric trajectory which takes a limited account of the contributions made by other cultural areas to the development of mathematical knowledge. There is some awareness of

Figure 2: *The 'modified' Eurocentric trajectory*



the existence of mathematics before the Greeks and their debt to these earlier mathematical traditions in Babylonia and Egypt. But this awareness is likely to be tempered with a dismissive rejection of their importance compared to Greek mathematics – '[the]scrawling of children just learning to write as opposed to great literature'.[6]

The differences in character of the Greek contribution before and after Alexander are recognised to a limited extent in Figure 2 by a chronological separation of Greece from the Hellenistic world (where the Ptolemaic and Selucid dynasties were the crucial instrument of mathematical creation for that period). There is also a recognition of the Arabs, but merely as custodians of Greek learning during the so-called Dark Ages in Europe. * Their role as transmitters and creators of knowledge is ignored. So are the contributions of other civilisations – notably those of China and India – which are perceived as borrowers from Greek sources, as having made only minor contributions or as having an insignificant role in mainstream mathematical developments (i.e., developments culminating in European dominance). ** More recently, histories of mathematics carry separate chapters, serving as 'residual' dumps, entitled 'Oriental' mathematics or 'Indian/Chinese' mathematics, which are of marginal relevance to the mainstream themes pursued in these books.[8] This marginalisation of non-European mathematics is reflected in the nature of the scholarship that characterises the treatment of these subjects in successive text books. An 'openness' to more recent research findings, especially in the case of Indian and Chinese mathematics, is sadly missing. As a consequence, paraphrases of the contents of earlier texts or quotes from individuals whose scholarship or impartiality have been seriously questioned are reproduced in each succeeding generation of textbooks. ***

* In a review article Nisbet has pointed out how the myth of a renaissance occurring in Europe between the fifteenth and sixteenth centuries has persisted, in spite of overwhelming evidence to indicate that there was continuous intellectual development taking place in Europe from the twelfth century.[7]

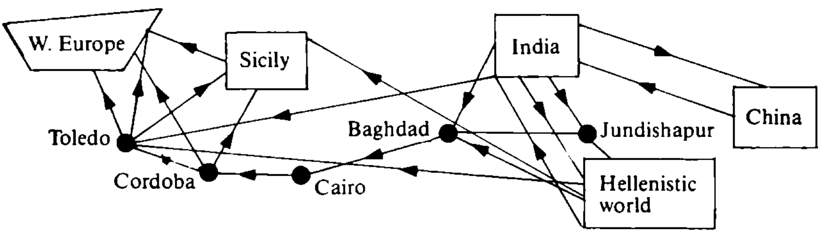
** Chinese, Mayan or Japanese mathematics are often ignored on the grounds that they fall outside the main line of mathematical development that culminated in the European advance of the subject.

*** One individual who is frequently quoted by historians as an authority on Indian mathematics is G.R. Kaye, who was in the service of the Raj at the turn of this century. His interpretations, both with regard to dating certain mathematical documents (notably *Sulbasutras* and the *Bakhshali Manuscript*) which he generally tended to put much later

Figure 2, therefore, remains a flawed representation of how mathematics developed over time. It encompasses a series of biases and remains impervious to new evidence and arguments. With minor modifications, it presents the model to which most books on the history of mathematics conform. While I propose in the next section to explore the nature and sources of the biases that such a representation reflects, it should be noted that similar Europe-centred bias exists in other disciplines as well. For example, diffusion theories in anthropology and social geography indicate that 'civilisation' spreads from the centre (i.e. 'greater' Europe) to the periphery (i.e. the rest of the world). Again, theories of modernisation or evolutionary schemes developed within the framework of certain brands of marxism are characterised by a similar type of Eurocentrism. In all such conceptual schemes, the development of Europe is seen to serve as a precedent for the way in which Third World societies will develop in the future – a trajectory whose spirit is not dissimilar to the one suggested in Figure 2.

Figure 3 offers an alternative trajectory of mathematical development, but concentrates mainly on filling in the details for the period represented by the arrow labelled 'Dark Ages' in Figures 1 and 2. The role of the Arabs is crucial here. Mathematical knowledge which originated in India, China and the Hellenistic world was sought out by Arab scholars and then translated, refined, synthesised and augmented at different centres of learning, starting with Jundishapur in South-east Persia and then moving to Baghdad, Cairo and, finally, to Toledo and Cordoba in Spain. Considerable resources were made available to the scholars through the benevolent patronage of the Caliphs of Abbasid (i.e., the rulers of the eastern Arab empire with its capital at Baghdad) and Ummayid (i.e., the rulers of the western Arab empire with its capital first at Damascus, then moving to Cairo and finally to Cordoba).

Figure 3: *An alternative trajectory (from 8th to 15th century)*



than other scholars, usually on fairly flimsy grounds, as well as his tendency to attribute anything significant in Indian mathematics to a Greek origin, have been criticised by notable scholars of ancient Indian mathematics,[9] without apparently making much impression on those who continue to write histories of mathematics in Europe and her cultural dependencies.

The Abbasid Caliphs, notably al-Mansur (754-775 AD), Harun al-Rashid (786-806 AD) and al-Mamun (813-833 AD), were in the forefront of promoting the study of astronomy and mathematics in Baghdad. Indian scientists were invited to settle in Baghdad. At the closure of Plato's Academy in 529 AD by the Roman Emperor Justinian to placate Christian bigotry, many of its scholars found refuge in Jundishapur in Persia, which a century later became part of the Arab world. Greek manuscripts from the Byzantine Empire, the translations of the Syriac schools of Antioch and Damascus and the remains of the Alexandrian library in the hands of the Nestorian Christians at Edessa were all sought out eagerly by Arab scholars, aided and abetted by the rulers who had control over or access to men and materials from the Byzantine Empire, Persia, Egypt, Syria and places as far east as India and China. Caliph al-Mansur built at Baghdad a *Bait al-Hikma* (translated as House of Wisdom) which contained a large library to stock the manuscripts that had been collected from various sources, an observatory which became a meeting-place of Indian, Chinese, Hellenistic and Babylonian astronomical traditions, and a university where scientific research continued apace. A notable member of this institution, Mohamed ibn-Musa al-Khwarizmi (c825 AD), wrote two books which were of crucial importance to the future development of mathematics. One of the books, the Arabic text of which is extant, is entitled *Hisab al-djabr wa-al Muqabala* (which may be translated as the 'science of reduction and cancellation' or, probably, 'science of equations') which introduced the word *al-djabr* (or algebra) for the first time. His second book, of which only a Latin translation is extant, is called *Algorithmi de numero Indorum*. It explained the Indian system of numeration, and was based on the work of Brahmagupta (c628 AD), an Indian mathematician-astronomer, entitled *Brahmasputa Siddhanta*. While al-Khwarizmi was at pains to point out the Indian origin of the numeration system, subsequent translations of the book attributed not only the book but the numerals to the author. Hence, in Europe any scheme using these numerals came to be known as an algorism or later algorithm (i.e., a corruption of the name al-Khwarizmi) and the numerals became Arabic numerals.

Other great Arab mathematicians continued the work begun by al-Khwarizmi, and they included Thabit ibn-Qurra (826-901), Abu-Kamil (c900), Abul-Wefa (940-998), Ibn al-Haytham (c965-1039), al-Biruni (973-1048), Omar Khayyam (c1050-1122), better known in the West as a poet and hedonist, and Nasir Eddin al-Tusi (1201-1274). The last named mathematician was no longer in the service of Arab rulers; he was an astronomer to the Mongol, Hulagu Khan, grandson of Genghis Khan. His contributions to non-Euclidean geometry, which formed the starting-point of the work of Saccheri of Italy five centuries later, show that Arab geometry had truly come of age after being tied initially to the apron strings of Hellenistic geometry.

Figure 3 highlights the importance of two areas of southern Europe in the transmission of mathematical knowledge to western Europe. Spain and Sicily were the nearest points of contact with Arab science and had been under Arab hegemony, with Cordoba succeeding Cairo as the capital and centre of learning of the Ummayid caliphate during the ninth and tenth centuries. Scholars from different parts of western Europe congregated in Cordoba and Toledo in search of both ancient and contemporary knowledge. As an illustration of this great thirst for knowledge, it is reported that Gherardo of Cremona (c1114-1187) went to Toledo, after its recapture by the Christians, in search of Ptolemy's *Almagest*, an astronomical work of great importance produced in Alexandria during the second century AD. He was so taken by the intellectual activity there that he remained for a period of twenty years, during which he was reported to have copied or translated eighty manuscripts of Arab mathematics or Greek classics, which he then proceeded to take back to his homeland. Gherardo was one of a number of European scholars, including Plato of Tivoli, Adelard of Bath and Robert of Chester, who flocked to Spain in search of knowledge.

There are two additional features of mathematical knowledge that Figure 3 serves to highlight. First, it is not generally recognised that practically all topics taught in school mathematics today are directly derived from the work of mathematicians originating outside western Europe before the twelfth century AD. The failure to recognise this fact is partly a function of the heavily Euro-centred nature of school curricula and partly due to the unwarranted neglect of the history (and particularly non-Eurocentric history) of mathematics in a typical mathematician's education. Second, Figure 3 shows the one-way traffic of mathematical knowledge into western Europe up to the fifteenth century. Thus the Arab mathematical renaissance between the eighth and twelfth centuries shaped and determined the pace of developments in the subject for the next five hundred years.

The anatomy of Eurocentric bias

The Eurocentric historiography of mathematics exhibits certain features which may explain the biases that result. First, there is a general disinclination to locate mathematics in a materialistic base and thus link its development with economic, political and cultural changes. Second, there is a tendency to perceive mathematical pursuits as confined to an elite, a select few who possess the requisite qualities or gifts denied to the vast majority of humanity. This is a view prevalent even today in the classroom and thus determines what is taught and who benefits from learning mathematics. Third, there is a widespread acceptance of the view that mathematical discovery can only follow from a rigorous application of a form of deductive axiomatic logic, which is perceived as a unique product of Greek mathematics. As a consequence, 'intuitive' or empirical methods are dismissed as of little relevance in mathematics. Finally, the presentation of mathematical results must conform to the formal and didactic style following the pattern set by the Greeks over 2,000 years ago. And, as a corollary, the validation of new additions to mathematical knowledge can only be undertaken by a small, self-selecting coterie whose control over the acquisition and dissemination of such knowledge through journals has a highly Eurocentric character today.

As an illustration of how the features listed above can create Eurocentric bias, let us examine the status ascribed to mathematical pursuits which do not conform to the criteria mentioned in the last paragraph, notably in Egypt and Mesopotamia before the emergence of Greek mathematics.

A commonly expressed view is that, before the Greeks, there was no mathematics in the sense of the characteristic intellectual activity which goes under that name today. The argument goes: pre-Greek mathematics had neither a well-defined concept of 'proof' nor any perception of the need for proof. Where the Egyptians or Mesopotamians were involved in activities which could be described as 'mathematics', these activities were purely utilitarian, such as the construction of calendars, parcelling out land, administration of harvests, organisation of public works (e.g., irrigation or flood control) or collection of taxes. Empirical rules were devised to help undertake these activities, but there is no evidence of any overt concern with abstractions and proofs which form the core of mathematics. In any case, the argument continues, the only evidence that we have to assess the mathematics of these two civilisations amounts to little more than the exercises that schoolchildren of today are expected to work out, which merely involve the application of certain rules or procedures; they are hardly 'proofs' of results which have universal application.

A response to this critique of pre-Greek mathematics may take two forms. The first relates to the validity of the above characterisation of Egyptian or Mesopotamian mathematics. The second raises broader questions about the nature and functions of mathematics.

The word 'proof' has different meanings, depending on its context and the state of development of the subject. To suggest that because existing documentary evidence does not exhibit the deductive axiomatic logical inference characteristic of much of modern mathematics, these cultures did not have a concept of proof, would be misleading. Generalisations about the area of a circle and the volume of a truncated pyramid are found in Egyptian mathematics. Checking the correctness of a division by a subsequent multiplication or verifying the solutions of different types of equation by the method of substitution are found in Babylonian mathematics. A method in common use in Europe until about a hundred years ago for solving linear equations is generally known as the method of false position.* This method was in common use to solve practical problems such as determining the potency of beer or obtaining optimal feed mixtures for cattle and poultry in Egyptian and Babylonian mathematics. As Gillings has argued,[10] Egyptian 'proofs' are rigorous without being symbolic, so that typical values of a variable are used and generalisation to any other values is immediate. Or again, generalisations of the methods used in solving algebraic problems contained in the Ahmes papyrus (c1650 BC) and the Moscow papyrus (c1850 BC), two of the most important mathematical documents from Egypt, involve applications of the same procedure to one example after another. To illustrate, consider one of the 'lesson texts' dating back to the time of the first Babylonian dynasty of Hammurabi (c1700 BC), translated and interpreted by Neugebauer.[11] For the sake of simplicity, I have converted the quantities expressed in base 60 (i.e., sexagesimal) system to our base 10 (i.e., decimal system).

Problem
Length (us), width (sag). I have multiplied length and breadth, thus obtaining the area. Then I added to the area the excess of length over width:183 (was the result). Then I have added length and width:27. Required (to obtain) length, width and area.

Solution
Given 27 and 183, the Sums
Result 15 length, 12 width, 180 area

Method
One follows this method: [step 1] $27 + 183 = 210$; $2 + 27 = 29$
Take one half of 29 and square it: [step 2] $(14.5)^2 = 210.25$
Subtract 210 from the result: [step 3] $210.25 - 210 = 0.25$
Take square root of 0.25: [step 4] Square root of $0.25 = 0.5$
Then, Length $= 14.5 + 0.5 = 15$
Breadth $= (14.5 - 0.5) - 2 = 12$
Area $= 15 \times 12 = 180$

Present-day method
Let length (us) = x and width (sag) = y. **Then the problem is solved by** evaluating the following two equations;

$$xy + x - y = 183$$
$$x + y = 27 \qquad (1)$$

Now define a new variable y' such that $y' = y + 2$
Then (1) can be rewritten as:

$$xy' = 27 + 183 = 210$$
$$x + y' = 2 + 27 = 29 \qquad (2)$$

(*Note*: The transformation from (1) to (2) is indicated by Step 1)

* To solve for x in the equation $x + x/5 = 24$, the method of false position involves arguing that if $x = 5$, then $x + x/5$ will equal 6. So to obtain the required 24, we need to multiply 6 by 4. Or the correct x value is 20.

The general system of equations of which (2) is a particular case may be expressed thus;

$$xy' = P$$
$$x + y' = s$$

So that the solution is:

$$x = \tfrac{1}{2}s + w$$
$$y' = \tfrac{1}{2}s - w \qquad (3)$$

where

$$w = \text{Square root of } [(\tfrac{1}{2}s)^2 - P]$$

Substitution of $P = 210$, $s = 29$ gives $w = 0.5$, which can then be used to evaluate $x = 15$, $y = y' - 2 = 12$ and area $= 180$

What the Babylonian method involved was the application step by step of the general formula, expressed in modern algebraic symbolism, given in (3) to numbers. The Sumerian symbols *us* and *sag*, for length and width respectively, serve the same purpose as our algebraic symbols x and y. And instead of providing a formula for the solutions of this type of problem, the Babylonians gave one example after another, just as an elementary school textbook may do today to ensure that the method is correctly applied. Such a demonstration may very well be as effective as 'formal' proofs in problems of this nature. This problem is also indicative of the level of sophistication reached by Babylonian mathematics. To dismiss such work as 'scrawlings of children just learning to write'[12] is more a reflection of the author's prejudices than an objective assessment of the real quality of such mathematics.

A further criticism levelled against Egyptian and Babylonian mathematics is that their mathematics was more a practical tool than an intellectual pursuit. This criticism is symptomatic of a widespread attitude, again originating with the Greeks,* that mathematics devoid of an utilitarian bent is in some sense a nobler or better mathematics. This attitude has even percolated right across the mathematics curriculum in schools and colleges.** As a consequence, there is both a sense of remoteness and irrelevance associated with the subject among many who study it, and an ingrained elitism among those who teach it. This elitism is translated at a classroom level into a view, often implicit and not spoken, that real mathematics as opposed to 'doing sums' is an activity suited for a select few – which when extended provides the broader argument that mathematics is a unique product of European

* An important distinction running right across Greek thought was between *Arithmetica*, the study of the properties of pure numbers, and *Logistica*, the use of numbers in practical applications. The cultivation of the latter discipline was to be left to the slaves. A legend has it that when Euclid (c300 BC) was asked what was to be gained from studying geometry, he told his slave to toss a coin at the inquirer.

** There is, however, a discernible movement towards 'utilitarian' mathematics in the modern classroom. So the tide may be turning.

culture. Thus, elitism in the classroom is ultimately linked to the form of intellectual racism which I have described as Eurocentrism.

Countering Eurocentrism in the classroom

The foregoing analysis illustrates the need to confront and then counter Eurocentrism in mathematics. A commonly expressed view of the educational establishment in this country is that while a correction of the Eurocentric bias in history may be a worthwhile exercise, it has little relevance to mathematical activities within the classroom. I have stated elsewhere why I think this is a misconceived view and how an unbiased historical perspective can enrich the quality of mathematical activity in the classroom as well as provide a valuable input into anti-racist education generally.[13] It would be useful to restate these arguments in the context of the themes explored here.

First, mathematics is shown to have flourished all over the world, with its internal logic providing a point of convergence for different mathematical traditions, without being constrained by geography, gender* or race. Yet within this unity there is an interesting diversity which could serve to entertain and educate at the same time. By bringing to the attention of the students differences in the language and structure of counting systems found across the world, by showing how different calendars and eras operate or by examining different spatial relations contained in, say, traditional African designs, Indian *rangoli* patterns and Islamic art, they could serve both as useful examples of applied mathematics as well as increase their awareness of cultural diversity.**

Second, a historical approach may, if handled carefully, provide a useful materialistic perspective in evaluating contributions made by different societies. The implied myth of the 'Greek' miracle in explaining the origins of mathematics will give way to a more balanced assessment of the nature of early mathematical accomplishments. Thus, the Ishango bone, found on a fishing site by the banks of Lake Edward in Zaire dating back about 8,000 years, was first thought of as a permanent numerical record of unknown objects. A closer study of the notches on it revealed that it may have been a six-month calendar of the

* The contributions of women mathematicians have also been neglected in standard histories, except for the occasional mention of Hypatia (c.d.415) whose cruel death at the hands of a Christian mob is taken by some to represent the end of Alexandrian mathematics.[14]

** It is not my intention here to enter into the controversy regarding the precise meaning of culture. The relationship between a people who possess a culture and the culture itself is highly complex and very germane to the point under discussion. The term 'culture' is used here in an anthropological sense to describe a collection of customs, rituals, beliefs, tools, mores, etc., possessed by a group of people who may be related to one another by factors such as a common language, geographical contiguity or class.

phases of the moon.* Similarly, an Amerindian *quipi* found in Peru was first thought of as an art object consisting of an intricate pattern of woven knots. But it was later recognised that the artefact contained the record of a whole population census taken about 2,000 years ago, where the knots of varying sizes stood for different numerical magnitudes and different colour coding used to show characteristics such as sex and age. In a predominantly pastoral or simple agricultural economy such ingenious devices were invented to satisfy the main mathematical requirement – the recording and preservation of such information as was required to keep track of the passage of time or predict seasons for planting seeds or the coming of rains. But as societies evolved mathematical demands became more varied and sophisticated, leading, for example, to the discovery of the place value notation by Babylonians (c2000 BC) for more complex computations and the eventual adoption 3,000 years later, when mechanical contrivances such as the abacus or rod numerals were no longer sufficient, of our number system (developed by the Indians about 2,000 years ago), when written calculations became absolutely essential for trade and commerce. Both the Babylonian invention and the Indian numerals were momentous discoveries at the time, but are taken for granted today.

Finally, if we accept the principle that teaching should be tailored to children's experience of the social and physical environment in which they live, mathematics should also draw on these experiences, which would include in contemporary Britain the presence of different ethnic minorities with their own mathematical heritage. Drawing on the mathematical traditions of these groups, indicating that these cultures are recognised and valued, would also help to counter the entrenched historical devaluation of them. Again, by promoting such an approach, mathematics is brought into contact with a wide range of disciplines, including art and design, history and social studies, which it conventionally ignores. Such a holistic approach would serve to augment, rather than fragment, a child's understanding and imagination.

References

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* Marshack has argued, on the basis of a close fit observed between the numbers in each group of notches and the astronomical lunar periods, that the Ishango bone offers possible evidence of one of man's earliest intellectual activities, devising sequential notation based on a six-month lunar calendar for activities such as tattooing, decorating, gaming or ceremonial festivities.[15]

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11 O. Neugebauer, *Mathematische Keilschrift-Text*, Vol. 2 (Berlin, 1935), p. 113.
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14 A useful beginning, though concentrating on women mathematicians in Europe and the US, is found in L.M. Osen, *Women in mathematics* (Cambridge, Mass., 1974).
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