ALAN J. BISHOP

Western mathematics: the secret weapon of cultural imperialism

Of all the school subjects which were imposed on indigenous pupils in the colonial schools, arguably the one which could have been considered the least culturally-loaded was mathematics. Even today, that belief prevails. Whereas educational arguments have taken place over which language(s) should be taught, what history or religion, and whether, for example, 'French civilisation' is an appropriate school subject for pupils living thousands of kilometres from France, mathematics has somehow always been felt to be universal and, therefore, culture-free. It had in colonial times, and for most people it continues to have today, the status of a culturally neutral phenomenon in the otherwise turbulent waters of education and imperialism.

This article challenges that myth, and places what many now call 'western mathematics' in its rightful position in the arguments – namely, as one of the most powerful weapons in the imposition of western culture.

Up to fifteen years or so ago, the conventional wisdom was that mathematics was culture-free knowledge. After all, the popular argument went, two twos are four, a negative number times a negative number gives a positive number, and all triangles have angles which add up to 180 degrees. These are true statements the world over. They have universal validity. Surely, therefore, it follows that mathematics must be free from the influence of any culture?

There is no doubt that mathematical truths like those are universal. They are valid everywhere, because of their intentionally abstract and general nature. So, it doesn't matter where you are, if you draw a flat

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Alan J. Bishop teaches at the Department of Education, Cambridge University.

Race & Class, 32(2), (1990)

triangle, measure all the angles with a protractor, and add the degrees together, the total will always be approximately 180 degrees. (The 'approximate' nature is only due to the imperfections of drawing and measuring – if you were able to draw the ideal and perfect triangle, then the total would be exactly 180 degrees!) Because mathematical truths like these are abstractions from the real world, they are necessarily context-free and universal.

But where do 'degrees' come from? Why is the total 180? Why not 200, or 100? Indeed, why are we interested in triangles and their properties at all? The answer to all these questions is, essentially, 'because some people determined that it should be that way'. Mathematical ideas, like any other ideas, are humanly constructed. They have a cultural history.

The anthropological literature demonstrates for all who wish to see it that the mathematics which most people learn in contemporary schools is not the only mathematics that exists. For example, we are now aware of the fact that many different counting systems exist in the world. In Papua New Guinea, Lean has documented nearly 600 (there are more than 750 languages there) containing various cycles of numbers, not all base ten.[1] As well as finger counting, there is documented use of body counting, where one points to a part of the body and uses the name of that part as the number. Numbers are also recorded in knotted strings, carved on wooden tablets or on rocks, and beads are used, as well as many different written systems of numerals.[2] The richness is both fascinating and provocative for anyone imagining initially that theirs is the only system of counting and recording numbers.

Nor only is it in number that we find interesting differences. The conception of space which underlies Euclidean geometry is also only one conception – it relies particularly on the 'atomistic' and object-oriented ideas of points, lines, planes and solids. Other conceptions exist, such as that of the Navajos where space is neither subdivided nor objectified, and where everything is in motion.[3] Perhaps even more fundamentally, we are more aware of the forms of classification which are different from western hierarchical systems – Lancy, again in Papua New Guinea, identified what he referred to as 'edge-classification', which is more linear than hierarchical.[4] The language and logic of the Indo-European group have developed layers of abstract terms within the hierarchical classification matrix, but this has not happened in all language groups, resulting in different logics and in different ways of relating phenomena.

Facts like these challenge fundamental assumptions and long-held beliefs about mathematics. Recognising symbolisations of alternative arithmetics, geometries and logics implies that we should, therefore, raise the question of whether alternative mathematical systems exist.

Some would argue[5] that facts like those above already demonstrate the existence of what they call 'ethno-mathematics', a more localised and specific set of mathematical ideas which may not aim to be as general nor as systematised as 'mainstream' mathematics. Clearly, it is now possible to put forward the thesis that all cultures have generated mathematical ideas, just as all cultures have generated language, religion, morals, customs and kinship systems. Mathematics is now starting to be understood as a pan-cultural phenomenon.[6]

We must, therefore, henceforth take much more care with our labels. We cannot now talk about 'mathematics' without being more specific, unless we are referring to the generic form (like language, religion, etc.). The particular kind of mathematics which is now the internationalised subject most of us recognise is a product of a cultural history, and in the last three centuries of that history, it was developing as part of western European culture (if that is a well-defined term). That is why the title of this article refers to 'western mathematics'. In a sense, that term is also inappropriate, since many cultures have contributed to this knowledge and there are many practising mathematicians all over the world who would object to being thought of as western cultural researchers developing a part of western culture. Indeed, the history of western mathematics is itself being rewritten at present as more evidence comes to light, but more of that later. Nevertheless, in my view it is thoroughly appropriate to identify 'western mathematics', since it was western culture, and more specifically western European culture, which played such a powerful role in achieving the goals of imperialism.[7]

There seem to have been three major mediating agents in the process of cultural invasion in colonised countries by western mathematics: trade, administration and education.[8] Regarding trade and the commercial field generally, this is clearly the area where measures, units, numbers, currency and some geometric notions were employed. More specifically, it would have been western ideas of length, area, volume, weight, time and money which would have been imposed on the indigenous societies.

If there was any knowledge of indigenous measure systems at all, or even currency units, there is little reference made to them in the literature. Researchers have only fairly recently begun to document this area and it is perfectly clear that many indigenous systems did (and do) exist.[9] Nevertheless, the units used in trade were (and still are) almost entirely western, and those local units which have survived are either becoming more and more westernised or are in the process of dying out. In some cases, there were simply no local units for measuring the kinds of quantities needed to be used by the western traders – as Jones' informant showed in Papua New Guinea in a recent investigation: 'It could be said [that two gardens are equal in area] but it would always be debated' and 'There is no way of comparing the volume of rock with the volume of water, there being no reason for it'.[10]

The second way in which western mathematics would have impinged on other cultures is through the mechanisms of administration and government. In particular, the numbers and computations necessary for keeping track of large numbers of people and commodities would have necessitated western numerical procedures being used in most cases. According to the research evidence, the vast majority of counting systems in the world are and were finite and limited in nature, and with a variety of different numerical bases. There is certainly evidence of some systems being able to handle large numbers in sophisticated ways if the societal needs are there (e.g., by the Igbo people and the Incas),[11] but though these, and presumably others, did exist, there was little evidence that they were even known by the colonial administrators, let alone encouraged or used. The one exception would have been the use by the Chinese, and by other people, of the abacus in certain colonies, which clearly was felt to be a sufficiently sophisticated system for administrative purposes.[12]

The other aspect to be imposed through administration would have been the language of hierarchy, through structuring people and their functions. It may seem a relatively insignificant example to choose, but it is very difficult for anyone used to the western obsession with naming and classification to imagine that there exist other ways of conceptualising and using language. The research of Lancy and of Philp have made us aware of this. As Lancy, for example, says:

> In Britain, parents teach their children that the most important function of language is reference. They prepare their children for a society that places a premium on knowing the names and classes of things. The Kaluli of the Southern Highlands of PNG invest – if anything – more time in teaching language to their children than do the British, but their aim is very different. The Kaluli child learns that the most important language functions are expressive; specifically, that the competent language user is one who can use speech to manipulate and control the behavior of others.

Any enforced use of other language structures is thus likely to cause difficulties and confusion,[13] but, more than that, any western European colonial governmental and administrative activity which concerned system, structure and the role of personnel would inevitably, and perhaps unwittingly, have imposed a western European mode of linguistic and logical classification.

The third and major medium for cultural invasion was education, which played such a critical role in promoting western mathematical ideas and, thereby, western culture. In most colonial societies, the imposed education functioned at two levels, mirroring what existed in the European country concerned. The first level, that of elementary education, developed hardly at all in the early colonial period. In India, for example, the 'filtering down' principle, whereby it was assumed that it was only necessary to educate the elite few and the knowledge would somehow 'filter down to the masses', was paramount. In some of the mission schools and in the latter years of colonialism when elementary schooling began to be taken more seriously, it was, of course, the European content which dominated. The need was felt to educate the indigenous people only in order to enable them to function adequately in the European-dominated trade, commercial and administrative structures which had been established. Mathematically, the only content of any significance was arithmetic with its related applications.[14]

Of much more interest to the theme of this essay is the secondary education given to the elite few in the colonised countries. In India and Africa, schools and colleges were established which, in their education, mirrored once again their comparable institutions in the 'home' country.[15] The fact that the education differed in French-controlled institutions from their English counterparts merely reflected the differences existing in the current philosophies of French and English education.

At best, the mathematics curriculum of some of the schools was just laughably and pathetically inappropriate. Mmari quotes some typical problems from Tanzanian colonial textbooks (recommended for use in schools by British colonial education officers):[16]

> If a cricketer scores altogether r runs in x innings, n times not out, his average is $\frac{r}{x-n}$ runs. Find his average if he scores 204 runs in 15 innings, 3 times not out.
>
> Reduce 207,042 farthings; 89,761 half-pence; 5,708 ½ shillings to £.s.d.
>
> The escalator at the Holborn tube station is 156 feet long and makes the ascent in 65 seconds. Find the speed in miles per hour.

But then, 'appropriateness' was entirely judged in terms of cultural transmission.

At worst, the mathematics curriculum was abstract, irrelevant, selective and elitist – as indeed it was in Europe – governed by structures like the Cambridge Overseas Certificate, and culturally laden to a very high degree.[17] It was part of a deliberate strategy of acculturation – intentional in its efforts to instruct in 'the best of the West', and convinced of its superiority to any indigenous mathematical systems and culture. As it was essentially a university-preparatory education, the aspirations of the students were towards attending western universities. They were educated away from their culture and away from their society. For example, Watson quotes Wilkinson, criticising Malayan education at the turn of the century in these terms: 'unpractical, to make the people litigious, to inspire a distaste for manual and technical work and to create a class of literary malcontents, useless to their communities and a source of trouble to the Empire'.[18] Mathematics and science – subjects which, in fact, could so easily have made connections with the indigenous culture and environment, and which could have been made relevant to the needs of the indigenous society – were just not thought of in those terms, despite many of the teachers' good intentions. They were seen merely as two of the pillars of western culture, significant as part of a cultured person's education in the nineteenth and early twentieth centuries.[19]

So, it is clear that through the three media of trade, administration and education, the symbolisations and structures of western mathematics would have been imposed on the indigenous cultures just as significantly as were those linguistic symbolisations and structures of English, French, Dutch or whichever was the European language of the particular dominant colonial power in the country.

However, also like a language, the particular symbolisations used were, in a way, the least significant aspect of mathematics. Of far more importance, particularly in cultural terms, were the values which the symbolisations carried with them. Of course, it goes without saying that it was also conventional wisdom that mathematics was value free. How could it have values if it was universal and culture free? We now know better, and an analysis of the historical, anthropological and cross-cultural literatures suggests that there are four clusters of values which are associated with western European mathematics, and which must have had a tremendous impact on the indigenous cultures.

First, there is the area of rationalism, which is at the very heart of western mathematics. If one had to choose a single value and attribute which has guaranteed the power and authority of mathematics within western culture, it is rationalism. As Kline says: 'In its broadest aspect mathematics is a spirit, the spirit of rationality. It is this spirit that challenges, stimulates, invigorates, and drives human minds to exercise themselves to the fullest.'[20] With its focus on deductive reasoning and logic, it poured scorn on mere trial and error practices, traditional wisdom and witchcraft. So, consider this quotation, from Gay and Cole in Liberia:

> A Kpelle college student accepted *all* the following statements: (1) the Bible is literally true, thus all living things were created in the six days described in Genesis; (2) the Bible is a book like other books, written by relatively primitive peoples over a long period of

> time and contains contradiction and error; (3) all living things have gradually evolved over millions of years from primitive matter; (4) a 'spirit' tree in a nearby village had been cut down, had put itself back together, and had grown to full size again in one day. He had learned these statements from his Fundamentalist pastor, his college bible course, his zoology course, and the still-pervasive animist culture. He accepted all, because all were sanctioned by authorities to which he feels he must pay respect.[21]

One can understand Gay and Cole's discomfort at this revelation, but one can also understand how much more confusing it must have been to the student to learn that anything which was not 'rational' in the western sense was not to be trusted.

Second, a complementary set of values associated with western mathematics can be termed objectism, a way of perceiving the world as if it were composed of discrete objects, able to be removed and abstracted, so to speak, from their context. To decontextualise, in order to be able to generalise, is at the heart of western mathematics and science; but if your culture encourages you to believe, instead, that everything belongs and exists in its relationship with everything else, then removing it from its context makes it literally meaningless. In early Greek civilisation, there was also a deep controversy over 'object' or 'process' as the fundamental core of being. Heraclitos, in 600-500BC, argued that the essential feature of phenomena is that they are always in flux, always moving and always changing. Democritus, and the Pythagoreans, preferred the world-view of 'atoms', which eventually was to prevail and develop within western mathematics and science.[22]

Horton sees objectism in another light. He compares this view with what he sees as the preferred African use of personal idiom as explanation. He argues that this has developed for the traditional African the sense that the personal and social 'world' is knowable, whereas the impersonal and the 'world of things' is essentially unknowable. The opposite tendency holds for the westerner. Horton's argument proceeds as follows:

> In complex, rapidly changing industrial societies the human scene is in flux. Order, regularity, predictability, simplicity, all these seem lamentably absent. It is in the world of inanimate things that such qualities are most readily seen. This is why many people can find themselves less at home with their fellow men than with things. And this too, I suggest, is why the mind in quest of explanatory analogies turns most readily to the inanimate. In the traditional societies of Africa, we find the situation reversed. The human scene is the locus *par excellence* of order, predictability, regularity. In the world of the inanimate [by which he means 'natural' rather than man-made],

> these qualities are far less evident. Here being less at home with people than with things is unimaginable. And here, the mind in quest of explanatory analogies turns naturally to people and their relation.[23]

We can see, therefore, that with both rationalism and objectism as core values, western mathematics presents a dehumanised, objectified, ideological world-view which will emerge necessarily through mathematics teaching of the traditional colonial kind.

A third set of values concerns the power and control aspect of western mathematics. Mathematical ideas are used either as directly applicable concepts and techniques, or indirectly through science and technology, as ways to control the physical and social environment. As Schaaf says in relation to the history of mathematics: 'The spirit of the nineteenth and twentieth centuries, is typified by man's increasing mastery over his physical environment.'[24] So, using numbers and measurements in trade, industry, commerce and administration would all have emphasised the power and control values of mathematics. It was (and still is) so clearly useful knowledge, powerful knowledge, and it seduced the majority of peoples who came into contact with it.

However, a complementary set of values, which is concerned with progress and change, has also grown and developed in order to gain yet more control over one's environment. An awareness of the values of control allied to the rational analysis of problems feeds a complementary value of rational progress, and so there is a concern to question, to doubt and to enquire into alternatives. Horton again points to this value when he contrasts western scientific ideas with traditional African values: 'In traditional cultures there is no developed awareness of alternatives to the established body of theoretical tenets; whereas in scientifically oriented cultures such an awareness is highly developed'.[25] Whether that conclusion has validity or not, there can be no doubting the unsettling effect of an elitist education which was preaching 'control' and 'progress' in traditional societies, nor could one imagine that these values were what was needed by the indigenous population in the countries concerned.

Certainly, even if progress were sought by the indigenous population, which itself is not necessarily obvious, what was offered was a westernised, industrialised and product-oriented version of progress, which seemed only to reinforce the disparity between progressive, dynamic and aggressive western European imperialists and traditional, stable and non-proselytising colonised peoples. Mathematically inspired progress through technology and science was clearly one of the reasons why the colonial powers had progressed as far as they had, and that is why mathematics was such a significant tool in the cultural kitbag of the imperialists.

In total, then, these values amount to a mathematico-technological cultural force, which is what indeed the imperialist powers generally represented. Mathematics with its clear rationalism, and cold logic, its precision, its so-called 'objective' facts (seemingly culture and value free), its lack of human frailty, its power to predict and to control, its encouragement to challenge and to question, and its thrust towards yet more secure knowledge, was a most powerful weapon indeed. When allied to the use of technology, to the development of industry and commerce through scientific applications and to the increasing utility of tangible, commercial products, its status was felt to be indisputable.

From those colonial times through to today, the power of this mathematico-technological culture has grown apace – so much so that western mathematics is taught nowadays in every country in the world. Once again, it is mainly taught with the assumptions of universality and cultural neutrality. From colonialism through to neo-colonialism, the cultural imperialism of western mathematics has yet to be fully realised and understood. Gradually, greater understanding of its impact is being acquired, but one must wonder whether its all-pervading influence is now out of control.

As awareness of the cultural nature and influence of western mathematics is spreading and developing, so various levels of responses can also be seen. At the first level, there is an increasing interest in the study of ethno-mathematics, through both analyses of the anthropological literature and investigations in real-life situations. Whilst recognising that many now-important ideas may well not have seemed to be so by earlier generations of anthropologists, there is, nevertheless, still a great deal of information to be gleaned from the existing literature.

This kind of literature analysis is, of course, aided by theoretical structures which help us conceptualise just what mathematics, as the pan-cultural phenomenon, might be. It is reiterated that mathematics is a cultural product – a symbolic technology, developed through engaging in various environmental activities.[26] Six universal activities may be identified, by which I mean that no cultural group has been documented which does not appear to carry out these activities in some form.[27] They are:

- Counting: the use of a systematic way to compare and order discrete objects. It may involve body or finger counting, tallying, or using objects or string to record, or special number names. Calculation can also be done with the numbers, with magical and predictive properties associated with some of them.
- Locating: exploring one's spatial environment, and conceptualising and symbolising that environment, with models, maps, drawings and other devices. This is the aspect of geometry where orientation,

navigation, astronomy and geography play a strong role.

- Measuring: quantifying qualities like length and weight, for the purposes of comparing and ordering objects. Measuring is usually used where phenomena cannot be counted (e.g., water, rice), but money is also a unit of measure of economic worth.
- Designing: creating a shape or a design for an object or for any part of one's spatial environment. It may involve making the object as a copyable 'template', or drawing it in some conventionalised way. The object can be designed for technological or spiritual uses and 'shape' is a fundamental geometrical concept.
- Playing: devising, and engaging in, games and pastimes with more or less formalised rules that all players must abide by. Games frequently model a significant aspect of social reality, and often involve hypothetical reasoning.
- Explaining: finding ways to represent the relationships between phenomena. In particular, exploring the 'patterns' of number, location, measure and design, which create an 'inner world' of mathematical relationships which model, and thereby explain, the outer world of reality.[28]

We now have extensive documentary evidence from many different cultures confirming the existence of all of these activities, and this structure is one which is enabling more detailed searches to be undertaken in the research literature. Ethno-mathematics is, however, still not a well-defined term,[29] and, indeed, in view of the ideas and data we now have, perhaps it would be better not to use that term but rather to be more precise about which, and whose, mathematics one is referring to in any context. Moreover, the search should also focus on the values aspect as well. In considering the problems and issues of culture-conflict in education, it is all too easy to remain at the level of symbolisations and language, whereas of much more significance educationally are the differences in cultural values which may exist. They need serious attention in future research.

At the second level, there is a response in many developing countries and former colonies which is aimed at creating a greater awareness of one's own culture. Cultural rebirth or reawakening is a recognised goal of the educational process in several countries. Gerdes, in Mozambique, is a mathematics educator who has done a great deal of work in this area. He seeks not only to demonstrate important mathematical aspects of Mozambican society, but also to develop the process of 'defreezing' the 'frozen' mathematics which he uncovers. For example, with the plaiting methods used by fishermen to make their fish traps, he demonstrates significant geometric ideas which could easily be assimilated into the mathematics curriculum in order to create what he considers to be a genuine Mozambican mathematics education for the young people there.[30]

Clearly, the ideas of the first level will inform and stimulate work at this second level – another reason why ethno-mathematical research needs to be updated. This activity is not restricted to developing countries either. In Australia with the Aborigines, in North America with the Navajos and other Amerindian groups and in other countries where there exist cultural and ethnic minorities, there is a great deal of interest in discovering and developing local, folk or indigenous mathematics which may have been lying dormant for many centuries.[31] These ideas may then help to shape a more relevant, and culturally meaningful, curriculum in the local schools.

One of the greatest ironies in this whole field is that several different cultures and societies have contributed to the development of what is called western mathematics: the Egyptians, the Chinese, the Indians, the Arabs, the Greeks, as well as the western Europeans. Yet when western cultural imperialism imposed its version of mathematics on the colonised societies, it was scarcely recognisable as anything to which these societies might have contributed. In Iran, in the early 1970s, for example, there appeared to be little awareness amongst the local mathematics educators of the massive contribution which the Muslim empire had made to the development of the mathematics which they were struggling to teach to their young people. Nowadays, with the rise of fundamentalism, there is growing an increasing awareness of both this contribution and also of an essential Islamic philosophy of education, which will shape the mathematical and scientific curricula in the fundamentalist schools.[32] We are, therefore, beginning to see the assimilation, in place of the imposition, of western mathematics into other cultures. This is a world-wide development and can only help to stimulate cultural regrowth.

The third level of response to the cultural imperialism of western mathematics is, paradoxically, to re-examine the whole history of western mathematics itself. It is no accident that this history has been written predominantly by white, male, western European or American researchers, and there is a concern that, for example, the contribution of Black Africa has been undervalued. Van Sertima's book *Blacks in Science* is a deliberate attack on this prejudiced view of mathematical development.[33] Various contributors to this book point to the scientific, technological and mathematical ideas and inventions developed in Africa centuries ago, yet rarely referred to. Other contributors argue that the contribution of the Greeks to mathematics has been over-emphasised; that they only consolidated and structured what had been thoroughly developed by the Babylonians and the Egyptians earlier; that Euclid worked in Alexandria and is more likely to have been African rather than Greek; that the archaelogical evidence has either been ignored or misrepresented.[34]

Joseph[35] emphasises the strong role played by the Muslim empire in bringing mathematical ideas from the East to the notice of a wider people, not just in Europe. Needham's work[36] demonstrates very well the contributions which began in China and grew through India where the Muslims made contact with them. There is certainly no reason to claim that what we know as western mathematics was entirely the product of western European culture.

In my view, however, the significance of cultural values has been underestimated in much of this historical analysis so far, and that when that dimension is fully recognised, there will be a great deal more re-analysing to do. The separation of symbolisations from cultural values is difficult to achieve, but we know how even the language of English carries different messages on both sides of the Atlantic because of the different cultural values existing there. The same symbolisations of mathematics may well have carried with them different kinds of values in different cultures in the past. Perhaps the best example of this is with India. Indian mathematics, along with that of other eastern cultural groups, had strong religious and spiritual values associated with it. Western mathematics on the other hand, was identified strongly with western science, with dehumanised, so-called 'objective' knowledge, and with empirical and rational interpretations of natural phenomena. Yet, in most Indian schools today, it is western mathematics which is taught and it is the western values that are thereby fostered. Of course, many of the symbolisations (numbers, etc.) are the bases for our own symbolisations and many of the ideas of arithmetic were developed by the Hindus. The values, though, are markedly different. Some Indian mathematics educators[37] are now arguing for developments to redress the balance, although a further irony is that there may well be more interest in this kind of educational development among the Indian community in, for example, England than in India, where the educational conflicts are apparently felt less deeply. Nevertheless, the relationship between values and symbolisations is likely to be a promising area for further research.

I began by describing the myth of western mathematics' cultural neutrality. Increasingly, modern evidence serves to destroy this naive belief. Nevertheless, the belief in that myth has had, and continues to have, powerful implications. Those implications relate to education, to national developments and to a continuation of cultural imperialism. Indeed, it is not too sweeping to state that most of the modern world has accepted western mathematics, values included, as a fundamental part of its education. In Hungary in 1988 the Sixth International Congress on Mathematics Education (which is held every four years) was attended by around 3,000 mathematics educators. They came from every country in the world that was able to support participation, and those that were not there will now be purchasing copies of the proceedings and the reports. Such is the magnet of western mathematics and its principal acolyte, western mathematics education. Clearly, many societies have recognised the benefits to their peoples of adopting western mathematics, science and technology.

However, taking a broader view, one must ask: should there not be more resistance to this cultural hegemony? Indeed, there is some awareness to build on. In addition to the three major responses mentioned earlier, in recent years, as the kinds of evidence and issues referred to in this article have become more widely disseminated and more seriously discussed, so there has grown a recognition of the need to reflect these concerns at such congresses. At the Hungary conference, one whole day was given over to the theme of 'Mathematics, education and society' on which many papers were presented, discussion stimulated and awareness kindled. Included in that day's programme were topics central to the issues discussed here.[38]

Resistance is growing, critical debate is informing theoretical development, and research is increasing, particularly in educational situations where culture-conflict is recognised. The secret weapon is secret no longer.

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5 See, for example, U. d'Ambrosio 'Ethnomathematics and its place in the history and pedagogy of mathematics', *For the Learning of Mathematics* (1985), and P. Gerdes, 'How to recognise hidden geometrical thinking: a contribution to the development of anthropological mathematics', *For the Learning of Mathematics* (1986).

6 'Pan-cultural' is used to convey the sense that all cultures engage in mathematical activities.

7 In the late nineteenth century and early twentieth century, one can also recognise the increasing contribution of American and Australian influences, which nevertheless stem from the western European cultural tradition.

8 A fourth candidate would be 'technology'. Its influence is clear: see, for example, D.R. Headrick's *The Tools of Empire* (Oxford, 1981); but what is rather less clear is the mathematical relationship with technology. As science and mathematics developed in their power and control, they undoubtedly influenced technology, particularly later in the imperialist era.

9 See Zaslavsky, op. cit. and Menninger, op. cit.

10 J. Jones, *Cognitive Studies with Students in Papua New Guinea* (Papua New Guinea, 1974).

11 See Ascher, op. cit.

12 Even today, the abacus has survived the calculator invasion and is still in prolific use in the countries of Asia.

13 See P.W. Bridgman, 'Quo Vadis', *Daedalus* (No. 87, 1958), and L.C.S. Dawe, 'The influence of a bilingual child's first language competence on reasoning in mathematics' (unpublished PhD thesis, University of Cambridge, 1982). As Awoniyi points out: 'A foreign language is more than a different set of words for the same ideas; it is a new and strange way of looking at things, an unfamiliar grouping of ideas', T.A. Awoniyi, 'Yoruba language and the schools system; a study in colonial language policy in Nigeria 1882 - 1952', *The International Journal of African Historical Studies* (Vol. VIII, 1975).

14 In the main, of course, there was felt to be little need for anything beyond reading, in order to understand either the bible translated into a local language, or simple work instructions. In India, after the orientalist phase, English was the language used predominantly in the schools and the acquisition of English became *the* goal of education to the exclusion of anything else.

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16 G.R.V. Mmari, 'The United Republic of Tanzania: mathematics for social transformation' in F.J. Swetz (ed.) *Socialist Mathematics Education* (Southampton, PA 1978). He also says: 'Textbooks of the period in question indicate the use of foreign units of measure of length, weight, capacity, volume, and currency which support this theory of direct interaction between business practices and the cultural background of the then dominant existing business community'.

17 P. Damerow says 'The transfer of the European mathematics curriculum to developing countries was closely associated with the establishment of schools for the elite by colonial administrations. Under these circumstances it seemed natural to simply copy European patterns', 'Individual development and cultural evolution of arithmetical thinking' in S. Strauss (ed.), *Ontogeny and Historical Development* (Pennsylvania, 1986).

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19 Indeed, there was no great attempt in the 'home' countries themselves to make science and mathematics relevant either.

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22 See C.A. Ronan, *The Cambridge Illustrated History of the World's Science* (Cambridge Press, 1983), and C.H. Waddington, *Tools for Thought* (St Albans, 1977), for a recent analysis.

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25 Horton, op. cit.

26 For a fuller examination of these ideas, see A.J. Bishop, *Mathematical Enculturation: a cultural perspective on mathematics education* (Dordrecht, Holland, 1988).

27 The caveat may perhaps seem unnecessary, but to a mathematician the word 'universal' does cause certain problems. For further discussion of this general issue, see G.P. Murdoch, 'The common denominator of cultures' in R. Linton (ed.), *The Science of Man in the World Crisis* (New York, 1945).

28 In order for mathematical knowledge to develop, it is necessary for these activities to integrate and to interact. Without this integration, the set of activities could be

argued to be pre-mathematical.

29 See d'Ambrosio op. cit. and M. Ascher and R. Ascher, 'Ethnomathematics', *History of Science* (Vol. XXIV, 1986) for different perspectives. The Aschersargue specifically for ethnomathematics to be the province of 'non-literate peoples', while d'Ambrosio's view encompasses all mathematical ideas not exposed by 'mainstream' mathematics.

30 See Gerdes (1986) op. cit. and P. Gerdes, 'On possible uses of traditional Angolan sand drawings in the mathematics classroom', *Educational Studies in Mathematics* (No. 19, 1988).

31 See P. Harris *Measurement in Tribal Aboriginal Communities* (Northern Territory Department of Education, Australia, 1980), and Closs, op. cit.

32 See S.H. Nasr, *Islamic Science: an illustrated study* (Essex, UK, 1976) and I.R. Al-Faruqi and A.D. Naseef, *Social and Natural Science: the Islamic perspective* (London, 1981).

33 I. van Sertima, *Blacks in Science* (New Brunswick, 1986).

34 For example, B. Lumpkin, 'Africa in the mainstream of mathematics history', in van Sertima, op. cit.

35 G.G. Joseph, 'Foundations of Eurocentrism in Mathematics', *Race and Class* (Vol. XXVIII, 1987).

36 See C.A. Ronan, *The Shorter Science and Civilization in China,* Vol. 2 (Cambridge, 1981).

37 See, for example, D.S. Kothari's keynote address in the *Proceedings of the Asian Regional Seminar of the Commonwealth Association of Science and Mathematics Educators* (London, 1978).

38 See A.J. Bishop, P. Damerow, P. Gerdes and C. Keitel, 'Mathematics, Education and Society' in A. Hirst and K. Hirst, *Proceedings of the Sixth International Congress on Mathematical Education* (University of Southampton, 1988); also, there is a special UNESCO publication of the whole day's papers and proceedings (C. Keitel, A.J. Bishop, P. Damerow and P. Gerdes *Mathematics, Education and Society* (Document Series 35, Paris, 1989)).