Ghadar Jari Hai

The Revolt Continues

Vol. VIII, No. 3, July-Sept 2014 — For private circulation only — Contribution Rs 25/-

Decolonising Math and Science Education

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Printed and published by:
K. Madhusudhan, on behalf of Lok Awaz Publishers & Distributors.

Printed at:
New Print Cottage, B-74, Okhla Industrial Area, Phase-2,
New Delhi-110 020

Published at:
E-392, Sanjay Colony, Okhla Phase-II, New Delhi-110 020

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www.ghadar.in

Editorial Policy

Ghadar Jari Hai is a platform for discussing Indian solutions to problems facing India. It is focused on understanding Indian history, philosophy and economic, political and other fields of knowledge, without the jaundiced eye of Eurocentrism.

All serious views, of whatever hue, are welcome as long as the author substantiates his/her argument and does not indulge in labeling, name-calling and ridicule. We are particularly interested in unraveling pre-British India and the changes brought about through British rule, since the colonial legacy continues to bear great significance for present-day Indian society. We believe that no shade of opinion has a monopoly over the truth and that if we all collaborate in this endeavour, we are quite capable of arriving at insights and solutions to our problems, much as our ancestors did. We seek to publish well-researched articles in various fields, which are communicative at the same time and do not indulge in excessive technical jargon.

Edit

From the times of Macaulay till today, we Indians have been told that western education is the pathway to success. We have been constantly reminded of the superiority of western maths and science. Unfortunately many Indians blindly imitate the West and when Western authority is challenged, they react in an insular and ignorant manner. The cover story in this issue tries to critically re-examine the history of western mathematics and science. In a thought provoking contribution C K Raju, who has deeply studied cultural foundations of mathematics and has thrown new light on the practicalities in Indian mathematical tradition and also non secular Christian theological connections with foundations of European Mathematics, explains how a truly universal mathematics and science can be taught in our universities.

Perspectives

Decolonising Math and Science Education

C. K. Raju

From Macaulay until today, the need for Western education has been justified on the grounds of science. The fact, however, is that most Western-educated people today know little or nothing of mathematics or science (as I have repeatedly demonstrated in public meetings). What they mostly learn is to blindly imitate the West, with the belief that the West is superior, and to accept Western authority. When Western authority is challenged, they typically react in an insular way: they attack the critic in broad generic terms ("Hindu nationalist", "Islamic fundamentalist"), misrepresent the critique in coarse ways ("don't reject everything Western" etc.) or just adopt a "superior" air and avoid addressing the critique altogether. This combination of ignorance and insularity is not accidental: both are desirable qualities in a Christian missionary who is required to preserve and propagate the most absurd beliefs. Indeed, for two centuries, the proponents of Western education have conveniently overlooked the fact that the Western university system was *designed* to produce missionaries ever since its inception during the Crusades, and that design objective persisted during subsequent centuries of control bu the church.[1]

Hence, for the last several years of the decolonisation movement, I have publicly[2] and repeatedly made clear that my demand is for a **critical re-examination** of Western mathematics and science. However, because of their ignorance (about mathematics and science), superstition (about Western superiority) and insularity (to any critique), as required of an ideal missionary, thsae Western educated seem incapable of such a critical re-examination; nor can they accept the critique. Hence, they are just paralysed into inaction, like animals in a circus are paralysed by the ringmaster.

Now, from Kant[3] to Macaulay, the argument for Western superiority was premised on a false history of science (this history should be correctly termed as Christian triumphalist history, not euphemistically a Eurocentric account). However, leave alone a re-examination of math and science per se, even a critical re-examination of its history seems as painful a process to the Western indoctrinated as asking astrologers to re-examine astrology. Hence, in the spirit of Kovoor's challenge prize to astrologers, I instituted a challenge prize of Rs two lakhs for historians several years ago'[4] just to expose their blind beliefs about the history of science. According to the Western history of mathematics, ("real") mathematics began with Euclid.[5] My challenge prize is offered for any serious evidence that Euclid existed. Needless to say, the prize stands unclaimed, but our school texts remain changed since authority, not evidence, is the sole basis of Western history.

The other related story is that the book Elements (which "Euclid" supposedly wrote, but which does not mention his name) was the first to articulate the understanding that "real" mathematics concerns metaphysical ("deductive") proof.[6] Now, books are usually written

[1] C. K .Raju, "Education as Counter-revolution", *Frontier Weekly* **46** (2013). http://www.frontierweekly.com/articles/vol-46/46-7/46-7-Decolonising%20Hard%20Sciences.html. This is an edited version. The original version was also published in the same weekly earlier, and is posted at http://ckraju.net/papers/Education-and-counter-revolution.pdf.

[2] C. K. Raju, "Be critical: choose what is best", The Sun, Malaysia, 29 Aug 2011, p. 16. Clip posted at http://ckraju.net/press/2011/the-Sun-29-Aug-2011-p16-clipping-ckr-response.gif.

[3] Immanuel Kant, "Of National Characteristics, so far as They Depend upon the Distinct Feeling of the Beautiful and Sublime", in Observations on the Feeling of the Beautiful and the Sublime, trans. John T. Goldthwait, University of California Press, Berkeley, 1991, pp. 110–1.

[4] For a re-announcement of this prize in the presence of the then Malaysian Deputy Minister of Higher Education, see the video, "Goodbye Euclid". (Links and other details are posted at http://ckraju.net/blog/?p=63.) This prize was naturally preceded by years of attempts to persuade insular Western scholars, as described in C. K. Raju, *Euclid and Jesus*, Multiversity, 2013.

[5] E.g. W. W. Rouse Ball, *A Short Account of the History of Mathematics*, Dover, New York,1960, pp. 1–2.

[6] E.g. Rouse Ball, cited above.

in response to prevailing social circumstances, so if a different author wrote the Elements at a different time, it could well have been for different reasons.[7] Accordingly, we need to set aside the story, and examine the book afresh to see what it actually says. Now, the most superficial reading of the Elements brings out the fact, totally contrary to the Western myth, that its very first proposition uses an empirical proof (as does the key 4th proposition). In an amazing display of long-term mass gullibility, not a single Western scholar noticed this conflict between story and fact for seven centuries after the Crusades when the Elements first came to Europe (ca.1125 CE). This despite the fact that this book was very widely read, for it became a standard text for Christian rational theologians (schoolmen).

Even more amusing is what Western scholars did when they finally did notice that story was incompatible with fact. Instead of rejecting as balderdash the whole Crusading fabrication of Euclid and his supposedly special philosophy of mathematics (aligned to Christian theology), Bertrand Russell et al. tried to "save the story". (It is a well known principle of the philosophy of science that any story/theory, howsoever far-fetched, can always be "saved" from any counter-evidence for any length of time by piling on the hypotheses: every fact can be countered with a new hypothesis. This is a principle that theologians frequently use to defend all sorts of fantastic beliefs.) Russell accepted on blind faith the story of Euclid and his purported intentions, and argued that facts could just as well be explained by adding the hypothesis that Euclid had made a serious mistake in executing those intentions! Euclid apparently slipped up in the very first proposition! So, Russell et al. removed it from the book, thus amending fact to fit story in the manner of metaphysicians. Further, in their respective tomes on the foundations of geometry, at the turn of the 20th century., both Russell and Hilbert replaced the key 4th proposition of the Elements (which uses an empirical proof) by a postulate (SAS postulate).[8] (Hilbert's synthetic geometry does not work beyond proposition 35, but more hypotheses can be piled on, and that is another story.[9])

In the spirit of teaching to blindly ape the "superior" West, that is how we have been teaching geometry in our school texts since about the 1970's! After all, it has never happened in all of history that our colonised educators applied basic common sense to stand up against something (anything) accepted in the West. Indeed, the whole of the present-day formalist philosophy of mathematics is built around that absurd story of Euclid and his supposedly special understanding of mathematics as metaphysics, a story which is dear to the post-Crusade church but *contrary* to all available evidence. I emphasise that the issue is not just a story: that religiously biased metaphysics damages the practical applications of mathematics to science and technology.

Indeed, the religious roots of Western mathematics, are obvious to all except those blinded by Western education. Proclus, the first historical commentator on the Elements, in his commentary, derives mathematics from mathesis,[10] and, like Socrates, in Plato's Meno,[11] explains the religious function of mathematics in arousing the soul from its forgetfulness of past lives, saying mathematics thus "leads to the blessed life". The related notion of the soul and its past lives was, however, cursed by the Church, during its war with "pagans",[12] culminating in the 6th century Church ban on all philosophy and mathematics.

Later, when its Crusades against Islam failed militarily, the Church needed a tool to persuade Muslims.

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[7] For a book-length elaboration of the very likely possibility that "Euclid" was a black woman who lived in Africa in the 5th c. CE and wrote the book Elements to defend her "pagan" faith against violent attacks by Christians, and who was hence raped and brutally killed in a church, see C. K. Raju, Euclid and Jesus: How and why the church changed mathematics and Christianity across two religious wars, Multiversity, 2013.

[8] For full details, see C. K. Raju, *Cultural Foundations of Mathematics*, Pearson Longman, 2007. (Project of History of Indian Science, Philosophy and Culture, vol. X.4.). For a simplified account, see *Euclid and Jesus*,cited above. For an online account, see e.g. C. K. Raju, "Towards Equity in Math Education 1. Good-Bye Euclid!", *Bharatiya Samajik Chintan* 7 (4) (New Series) (2009) pp. 255–264. http://ckraju.net/papers/MathEducation1Euclid.pdf.

[9] C. K. Raju, "Euclid and Hilbert", chp. in *Cultural Foundations of Mathematics*, cited above. For an easy account, see *Euclid and Jesus*, cited above.

[10] Proclus, *Commentary* (falsely translated title: *A Commentary on the First Book of Euclid's Elements*), trans. Glenn R. Morrow, Princeton University Press, Princeton, New Jersey, 1970, Prologue part 2, p. 37.

[11] Plato, *Meno*, in *Dialogues of Plato*, trans. B. Jowett, Encyclopaedia Britannica, Chicago, 1996, pp. 179–180.

[12] C. K. Raju, "The curse on 'cyclic' time", chp. 2 in *The Eleven Pictures of Time*, Sage, 2003.

To this end, like a chameleon, it changed its own theology to Christian rational theology, copied and adapted from Islamic rational theology (*Aql-i-kalam*). To hide this real process of mimicking the religious enemy, the Church concocted Euclid to claim ownership of reason, through its "friends", the early Greeks. The Church also "reinterpreted" Egyptian mystery geometry the way it had earlier "retold" the mystery of Isis as Iesu: where Proclus saw reason as a means to arouse the soul, the church reinterpreted "universal" reason as concerned solely with persuasion or "irrefragable proof" (which is what it then needed to achieve its political ambitions). Leading Western thinkers, even those opposed to the church, like Newton or Russell, fell easy victims to this potent mix.

The real history of (practical, non-religious) mathematics is startlingly different. The Greek and Roman incomprehension of all but the simplest fractions is manifest from their crude and primitive system of numerals (with no notation for fractions) and the way they abjectly failed to maintain the calendar they copied, with scant understanding, from the Egyptians. Despite Julian reform, Roman incapacity to even articulate the length of the year desynchronised the Easter ritual, within a century of the Nicene council, leading to the Hilari(o)us calendar reforms which failed. Even in the 16th century, during the Gregorian reform, Clavius could not state the length of the year as a fraction, but articulated it through a complex system of leap years. (Amusingly, we still use that grossly inferior Roman/Gregorian ritual calendar as our national calendar on the superstitious belief that everything Western is superior and secular. Our national festivals, supposedly secular, are defined only on that Christian ritual calendar.)

When Indian numerals first arrived in Christian Europe in the 10th century., from Cordoba, via the Hisab Al Hind of al Khwarizmi ("Algorismus") of Baghdad, the infallible Pope who also happened to be the leading Western mathematician of the time, fundamentally misunderstood them. Accustomed to the abacus (and having written a tome on it), he amusingly arranged for the construction of a special abacus for "Arabic numerals".[13] This, of course, defeated the whole purpose of efficient arithmetics through "algorithms". It took the Europeans at least five centuries (probably closer to eight) to fully abandon the abacus/exchequer, jetons (counting pieces), tally sticks and the like.

Like the word zero (derived from *sifr* = cipher, meaning mysterious code), the very names tell the same hilarious story of persistent European perplexity with the mathematics it imported. Thus, $\sqrt{2}$ is today called a "surd", which derives from the Latin surdus, meaning deaf. Why is $\sqrt{2}$ deaf? This is a typical translation howler, arising from the 12th century Toledan mass translations of Arabic books. In the *sulba sutra-s*, square roots were computed using the diagonal of a square; for example, $\sqrt{2}$ is the diagonal of the unit square. The Sanskrit word for diagonal, *karna*, also means ear, so "bad diagonal" was mistranslated as "bad ear", hence deaf! Another such howler is the word sine from Latin *sinus*, being a translation of the Arabic *jaib*, meaning pocket. What, after all, does trigonometry have to do with one's pocket? The actual term is the Arabic *jiba* (misread as *jaib* by the Mozharab and Jewish translators of Toledo). That, in turn, derives from the vernacular *jiva*, from the Sanskrit *jya* meaning chord. Zero, surd, and sine are just three examples (not counting the Pope's apices). The list of these European blunders about imported mathematics goes on.

These linguistic blunders were accompanied by conceptual confusion: *jya* or chord manifestly relates to the circle, the triangle is incidental, so trigonometry is better called circle-metry, and teaching it thus makes it a lot clearer and easier as I have demonstrated. Nevertheless, the

[8] For full details, see C. K. Raju, *Cultural Foundations of Mathematics*, Pearson Longman, 2007. (Project of History of Indian Science, Philosophy and Culture, vol. X.4.). For a simplified account, see *Euclid and Jesus*,cited above. For an online account, see e.g. C. K. Raju, "Towards Equity in Math Education 1. Good-Bye Euclid!", *Bharatiya Samajik Chintan* 7 (4) (New Series) (2009) pp. 255–264. http://ckraju.net/papers/MathEducation1Euclid.pdf.

[9] C. K. Raju, "Euclid and Hilbert", chp. in *Cultural Foundations of Mathematics*, cited above. For an easy account, see *Euclid and Jesus*, cited above.

[10] Proclus, *Commentary* (falsely translated title: *A Commentary on the First Book of Euclid's Elements*), trans. Glenn R. Morrow, Princeton University Press, Princeton, New Jersey, 1970, Prologue part 2, p. 37.

[11] Plato, *Meno*, in *Dialogues of Plato*, trans. B. Jowett, Encyclopaedia Britannica, Chicago, 1996, pp. 179–180.

[12] C. K. Raju, "The curse on 'cyclic' time", chp. 2 in *The Eleven Pictures of Time*, Sage, 2003.

[13] For an image of the pope's apices from a manuscript of 976 CE, see *Euclid and Jesus,* cited above, Fig. 11.1, p. 119.

indoctrinated colonised mind has so touching a faith in the West that Sam Pitroda, the chairman of the National Knowledge Commission, declared against me that the only way to teach trigonometry was to follow the Massive Open Online Courses (MIT MOOC).

The difference between circle-metry and trigonometry is highly non-trivial for the circle is a curved line, unlike a triangle which only involves straight lines. This is clear from what happened when the Indian calculus first arrived in Europe. While Fermat and Pascal enthusiastically accepted it, Galileo dithered, and Descartes pompously declared in his Geometry[14] that the ratios of curved and straight lines were "beyond the capacity of the human mind", presumably meaning the European mind with which he was familiar. The problem which perplexed the European mind was this: the ratio of the circumference of a circle (curved line) to its diameter (a straight line) is the number today denoted by the Greek letter π. This involves an infinite series, as in 3.14159... = 3+1/10+4/100+.., and was expressed in the imported Indian texts using various infinite series, such as the infinite series today wrongly named the "Leibniz series".[15] Europeans had barely begun to use "practical" arithmetic (introduced in the Jesuit syllabus only since ca. 1572), so they naturally failed to understand how to carry out such an infinite sum. Descartes naively thought that carrying out an infinite sum would take an eternity of time. This was complemented by his belief, deeply influenced by the Western religious view of mathematics as "perfect" and "eternal truth", that summing only a finite number of terms, howsoever many, though adequate for all practical purposes, was not "perfect", hence not mathematics. To reiterate, Descartes' confusion essentially arose from his superstitious belief in mathematics as "perfect" or eternal truth. Descartes and Galileo are hardly isolated examples: this confusion about infinity, intertwined with the Western theological notion of eternity, seems to be eternally recurrent in Western thought since the first creationist controversy over eternity raised by John Philoponus contra Proclus.

The West never overcame this confusion about infinity: but if we set aside Western theology, the sum of an infinite series is conceptually simple with zeroism or *sunyavada*. In fact, in the language of Brahmagupta, Indians used "unexpressed fractions", which would be described in formalist mathematics as rational functions. This corresponds to doing calculus using numbers which form a non-Archimedean field. (This is different from university-text calculus which uses formal reals which form an Archimedean field.) In a non-Archimedean field, limits are not unique, and infinitesimals must be discarded in a manner similar (but not identical) to everyday rounding. No one in the West has yet contemplated this possibility, though non-Archimedean fields do arise at an intermediate stage in non-standard analysis. Thus, despite typical bombast about the superiority and "rigour" of limits, the fact is that limits ensure nothing worthwhile except to promote that sense of superiority which characterises Christian triumphalist history from Orosius to Toynbee. In fact, contrary to the myth of progress, the current Western understanding of mathematics and calculus is a very clear case of regress.

Thus, there is no way in the calculus, as taught in university texts today, to differentiate a discontinuous function. However, the "laws of physics" are formulated as differential equations of some sort, and discontinuities do arise in the simplest cases, such as shock waves. (In cases, like the general theory of relativity, there is not even any way to shift to a statistical mechanics of atoms, for there is no such covariant statistical mechanics, and no such atomic description of matter in general relativity.) The Schwartz theory of distributions provides an inadequate remedy: while it allows discontinuous functions to be differentiated, it is a linear theory which does not allow distributions to be multiplied, and this multiplication is necessary since partial differential equations of physics are non-linear.

Thus, all the centuries-old attempts by Western mathematicians to understand calculus from Newton's fluxions to Schwartz distributions have resulted only in an *inferior* product, which merely introduces enormous and needless complexities, as in present-day school and university mathematics, and hinders the practical application of mathematics to science. Under the

[14] R. Descartes, *The Geometry*, trans. D. Eugene and M. L. Latham, Encyclopaedia Britannica, Chiacago 1996, Book 2, p. 544.

[15] E.g. Yuktidipika, 2.271; Karanapaddhati VI, 1. For an elaboration, see *Cultural Foundations of Mathematics*, chp. 3 cited earlier (p. 168).

influence of a false history of science, accompanied by foolish arguments from Kant to Macaulay, the colonised mind has mistaken an inferior product for a superior one. Hence, I have long been advocating a critical re-examination of current university mathematics, *both* its philosophy and pedagogy, not a compromise to preserve its bad philosophy by blaming its pedagogy. To reiterate, the difficulties of present-day mathematics only reflect European difficulties in understanding imported mathematics, because of their bad and theology-laden philosophy of mathematics, which must first be abandoned. However, as already stated, what stands in the way of a change is the indoctrinated (and bribed) colonised minds resulting from Western education. Neither they nor their masters can answer the above objections; nor are they willing to admit the truth of Western inferiority, and false history. Hence, their silence has been resounding in the last decade. It is a typical con-trick of theologians to pretend to meet an unanswerable objection by maintaining a "superior" silence.

Indeed, this Western confusion about the metaphysics of infinity/eternity (and the related metaphysics of "causality") permeates every aspect of science from quantum mechanics, and the renormalisation problem of quantum field theory to general relativity and cosmology. As already stated, Stephen Hawking's creationism (through his singularity theory) derives from a similar confusion about infinity as something terrifying, for a singularity is nothing but an infinity of some sort, as I have repeatedly explained earlier.[16]

Eliminating Christian superstitions from science is important for the future of science.[17] However, the above examples involve technicalities beyond most professional physicists and mathematicians. Therefore, a less technical example may be in order. Thus, for most people, the first lesson in serious science in school begins with Newton's "laws". Now, why are they called "laws"? How do we know that there are any "laws"? This belief in the "laws of nature" first arose as a Christian superstition, when the Crusading theologian Aquinas, laid down in his *Summa Theologica*[18] that his god ruled the world with eternal laws. This superstition was politically motivated, as I have explained elsewhere.[19] (Note also that one must discriminate between eternal and inflexible "laws" versus habits, as in Islam, or regularities or rta, for the latter can be broken, as I have also explained elsewhere.[20]) The immediate point here, however, is that this superstitious belief went straight from Christian theology into science.

But, is the belief scientific? Let us apply Popper's criterion, for example. Is there a way to refute this belief in the eternal "laws of nature"? Does the refutation of "Newton's laws" refute the belief? If so, does it stand refuted? Or can we hang on to the belief and argue that it was Newton who failed, not the belief? (Remember Euclid?) If so, it is irrefutable. Whether refuted, or irrefutable, it is unscientific in either case.

Indeed, the belief that the future is decided from the past through the "laws of nature" is *contrary* to our most basic mundane experience that *we* decide a tiny bit of the future, an experience repeated thousands of times each day by billions of people around the world, and therefore far more reliable than experiments in high-energy physics costing billions of dollars, which cannot therefore be readily replicated. This observation ("mundane causality") is fundamentally opposed to the belief ("mechanical causality") that the future is decided from the past by "laws of nature".[21]

Nevertheless, this Christian superstition about the "laws of nature" has been repeatedly used to attack Islam as unscientific,

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[16] C. K. Raju, *The Eleven Pictures of Time*, cited earlier.

[17] See, "De-theologising physics", part 3 of *The Eleven Pictures of Time*, cited earlier.

[18] Thomas Aquinas, *Summa Theologica*, *First part of the Second Part*, 91,1, http://www.newadvent.org/summa/2091.htm.

[19] C. K. Raju, "Benedict's maledicts", Zmag, http://zcommunications.org/benedicts-maledicts-by-c-k-raju, and http://ckraju.net/papers/Benedicts-Maledicts-by-c-k-rjau.pdf. Reprinted in *Indian Journal of Secularism*, **10**(3) (2006) pp. 79-90.

[20] For the difference between laws and habits, see C. K. Raju, "Islam and science", Keynote address at International Conference on Islam and Multiculturalism: Islam, Modern Science and Technology, Asia-Europe Institute, University of Malaya, 5-6 Jan 2013, http://www.ckraju.net/hps-aiu/Islam-and-Science-kl-paper.pdf. In *Islam and Multiculturalism: Islam, Modern Science, and Technology*, ed. Asia-Europe Institute, University of Malaya, and Organizatoin for Islamic Area Studies, Waseda University, Japan, 2013, pp. 1-14. For the difference between laws and rta, see minutes of the discussion posted at http://ckraju.net/usm/PSc-minutes.html.

[21] C. K. Raju, "Mundane time", chp.8 in *Time: Towards a Consistent Theory*, Kluwer Academic, Dordrecht, 1994. Fundamental Theories of Physics, vol. 65.

and particularly al Ghazali, as I have explained elsewhere.[22] On the contrary, it is science which must be modified to eliminate this superstition, as I have already done. However, because of the rigidly enforced Church tradition of "authorised knowledge", it seems beyond the capacity of the Western-educated mind to understand anything, even science, except as "authorised knowledge". (Specifically, scientific knowledge today is required to be authorised through the traditional Church system of *secretive* review, the value of which is farcically ranked by the authority which selects the reviewers.)[23] Unable to refute, and unwilling to confirm, these hapless minds are waiting indefinitely, like a computer which hangs, and needs to be booted afresh or junked.

To summarise, the belief that the West is superior, and hence must be imitated, is a result of Christian triumphalist history that all science is the work of Christians and their friends the early Greeks. This history was initially fabricated during the Crusades to justify the mass Latin translation of Arabic books from the Muslim religious enemy and to claim that the knowledge in those books was actually of Greek origin, hence a Christian inheritance. This false history developed during the Inquisition when people (e.g. Copernicus) were too frightened to acknowledge their non-Christian sources.[24] It then took off with the help of racist and colonial historians. The resulting belief that mathematics and science are Western in origin is contrary to the merest common sense: if mathematics and science represent universal knowledge, they must have originated in the same way everywhere. If not, then culturally specific features may need to be eliminated, since non-universal and inferior (what may be properly called "Western") mathematics and science is marked by an intrusion of church theology. This intrusion was natural, for the Church dominated the minds of Western men for over a thousand years, in the way that Church steeples dominated the European landscape.

As regards practical mathematics, the real history is that most school mathematic (arithmetic, algebra, "trigonometry", calculus) went from India to Europe, first via the Arabs and then directly in the 16th century Europeans failed to understand this imported mathematics, and the foremost European minds made many amusing blunders, especially about zero and infinite series. European blunders about zero arose because of the primitive Greek/Roman system of enumeration, as reflected in the Greek/Roman calendar, and it took Europeans five centuries to overcome those difficulties.[25]

European blunders about the Indian infinite series are more serious, and persist to this day. They arose because Europeans wrongly tried to put together two streams of imported mathematics: a religious one they imported from Egypt via the Greeks (but attributed to fictitious Greeks like "Euclid"), and a practical one imported from India.[26] Europeans failed to reconcile these two distinct streams of mathematics: they tried and failed to make practical mathematics "perfect". That is, the mathematics re-exported during colonialism was merely an inferior and complexified version of the mathematics that Europe imported earlier over the preceding thousand years. Critically re-examining this possibility or accepting the possibility of Western inferiority is traumatic for the colonised mind.

However, the repercussions of inferior Western mathematics are obvious in science: for example, Newton's physics failed just because Newton made time metaphysical, and he did that because he wanted to make calculus perfect, for he believed that "God wrote the eternal laws of nature in the perfect language of mathematics". The superstitious belief in "laws of nature" began as a Crusading Christian superstition, articulated by Aquinas, before creeping into science (as in "Newton's laws"). Similarly, today we have Stephen Hawking's creationist pseudo-science of singularities.[27] The perennial Western attempt to

[22] "Islam and science", cited above.

[23] C. K. Raju, "Benchmarking science: a critique of the ISI (Thomson-Reuters) index", USM-Prince Songkla Univ. conference, Hat Yai, Oct, 2011, http://ckraju.net/papers/Benchmarking-science-paper.pdf.

[24] C. K. Raju, *Is Science Western in origin?*, Multiversity, Penang, Daanish books, Delhi, 2009. Reprint Other India Bookstore, Goa, 2014.

[25] C. K. Raju, "Math wars and the epistemic divide in mathematics", chp. 8 in *Cultural Foundations of Mathematics*, cited above. An earlier version was presented at Episteme-1, Homi Bhabha Centre, Mumbai, 2005, http://www.hbcse.tifr.res.in/episteme/episteme-1/allabs/rajuabs.pdf, and http://www.hbcse.tifr.res.in/episteme1/themes/ckraju_finalpaper.

[26] "Math wars and the epistemic divide in mathematics",cited above

[27] For a detailed non-technical account, see *The Eleven Pictures of Time*, cited earlier.

understand infinity in relation to the Christian (post-Nicene) notion of eternity leads to various other problems in physics today, as I have elaborated elsewhere.[28]

So, what is the solution? Clearly to obtain a truly universal mathematics and science, we must first overthrow Western authoritative control of our education system and through it, the control of our minds. Second, as a secular country, we are constitutionally bound to teach religiously neutral mathematics,[29] irrespective of how the West teaches it, for we are *not* constitutionally bound to imitate the West. As for those comprador elements ("experts") who help the West control the system by advocating such imitation, under no circumstance should they be allowed to operate secretively from behind closed doors as they do today. These "experts" must be forced to function transparently, by publicly declaring any conflict of interests; they must openly defend their recommendations in public space; else they must be forcefully ejected to end this system of Western rule by colonised proxies. Further, ordinary people too must be consulted on education; that consultation is not a just a matter of inviting the public to comment in a comments box which functions like a black hole: objections must be publicly answered.

If we reject Western education in mathematics and science, what exactly do we replace it with? Is there a ready alternative? We have to recognise that this is a major challenge. Even in countries in which there were revolutionary changes of governments, such as the former Soviet Union, there was no accompanying cultural revolution. The counter-revolutionary force of Western education[30] therefore prevailed in the long run, and those revolutions hence failed. An interesting current instance is Iran where, despite a three-decade old agenda to change the education system, despite shutting down universities for some time, and despite full state support, no major change could be brought about, and Western education still prevails. Needless to say, the Western educated still represent the strongest counter-revolutionary force in the system.

However, a change in the teaching of mathematics *is* feasible, as I have demonstrated in teaching experiments[31] using alternative curricula, especially in "trigonometry" and calculus, using a different philosophy of mathematics called zeroism. (This is just *sunyavada*, but, since 2007, this is called zeroism to emphasise that the important issue is the practical benefits of that philosophy, and not fidelity to the texts of Nagarjuna.) This also allows number systems to be developed in a natural way, using ostensive definitions (as a matter of philosophy not merely pedagogy). Because acceptance of empirical inputs makes the whole subject much easier and more intuitive, it is very easy to extend this to all K-12 mathematics. Because zeroism is naturally adapted to computational mathematics, this can also be extended, in a straightforward way to most practical applications of higher mathematics, which invariably involve computation.

The major hindrances are our mathematics "experts": those whom the ignorant regard as knowledgeable on the strength of Western certificates of approval. These "experts" are unwilling

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[28] For a quick summary see the table in my Tehran talk 2014, posted at http://ckraju.net/papers/presentations/decolonizing-mathematics.pdf.

[29] See, the "Petition to teach religiously neutral mathematics" which has now gathered the requisite 50 signatures, http://www.ipetitions.com/petition/teach-religiously-neutral-mathematics. Also, http://ckraju.net/blog/?p=94.

[30] Education as counter-revolution" cited earlier.

[31] C. K. Raju, "Teaching mathematics with a different philosophy. 1: Formal mathematics as biased metaphysics." *Science and Culture*, **77** (2011) (7-8) pp. 274-79. http://www.scienceandculture-isna.org/July-aug-2011/03%20C%20K%20Raju.pdf. "Teaching mathematics with a different philosophy. 2: Calculus without limits." *Science and Culture*, **77** (2011) (7-8) pp. 280-86. http://www.scienceandculture-isna.org/July-aug-2011/04%20C%20K%20Raju2.pdf.

The solution is to change the "experts" not just the pedagogy

to recognise (or discuss) the possibility that a non-Western philosophy of mathematics can actually be superior to the Western misunderstanding of mathematics that they learnt to blindly imitate on the strength of some unexamined stories. They are unwilling to accept that the goal of doing mathematics and science must be practical benefit to the people of the country, not earning the goodwill of this or that authoritative Western mathematician or scientist. Likewise, the value of mathematics must come from its practical benefits, and not idle talk of its aesthetic or spiritual benefits which should be rejected as a crude con-trick: for, while I have no difficulty in appreciating the original Egyptian mystery geometry, I object strongly to its ugly reinterpretation by the Crusading Church, as propagated through the Western education system. (And it is manifest that for millions of students in our education system, mathematics is a nightmare not an aesthetic experience.)

The solution is to change the "experts" not just the pedagogy. Indeed, the centrally-funded Tata Institute of Fundamental Research, which has dominated the mathematics scene in post-independence India, has not responded to my public challenge[32] to show any practical benefits resulting from their mathematics output in the last half century. Failure to respond to such critiques should be treated as implicit acceptance of the critique, as in traditional Indian norms of debate, or the norms used in our current legal system.

A full-fledged curriculum has also been developed to teach statistics, especially for social scientists, since zeroism works much better for probability than measure-theoretic (Kolmogorov) probability and the frequentist or subjective interpretation.[33] Side by side an alternative syllabus has also been proposed for physics,[34],[35] but field trials on this are yet to be carried out.

Further, I have repeatedly conducted two regular courses (not merely trials) on an alternative history and philosophy of science, with a large body of international students, most from colonised countries.[36] Challenging and changing the existing Western history of science is an essential first step to end academic imperialism[37] by putting to rest the utterly false claim of Christian triumphalist history that the West is superior since all science is Western in origin. A video interview of the students of the first such HPS course by Claude Alvares is also publicly available.[38]

The Multiversity (the real one) has also been engaged in developing alternative curricula for the social sciences. The philosophy syllabus (designed only for India) is a truly transformative replacement to dull Western philosophy which is barely distinguishable from theology. Thus, an initial alternative structure is in place, but a much work and international cooperation is required. ■

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[32] C. K. Raju, "Kosambi the mathematician", *Special article, Economic and Political Weekly 44(20) May16–22 (2009) 33–45*

[33] C. K. Raju, "Probability in Ancient India", chp. 37 in *Handbook of the Philosophy of Science*, vol 7. *Philosophy of Statistics*, ed. Prasanta S. Bandyopadhyay and Malcolm R. Forster. General Editors: Dov M. Gabbay, Paul Thagard and John Woods. Elsevier, 2011, pp. 1175-1196. http://ckraju.net/papers/Probability-in-Ancient-India.pdf.

[34] C. K. Raju, "Decolonising math and science". In *Decolonizing our Universities*, Claude Alvares and Shad Faruqi ed., Citizens International and USM, 2012, chp. 13, pp. 162-195 Video is first 34 minutes of the one at http://vimeo.com/26506961.

[35] C. K. Raju, "Functional differential equations. 1: A new paradigm in physics", *Physics Education* (India), **29**(3), July-Sep 2013, Article 1. http://physedu.in/uploads/publication/11/200/29.3.1FDEs-in-physics-part-1.pdf, and "Functional differential equations. 2: The classical hydrogen atom", *Physics Education* (India), **29**(3), July-Sep 2013, Article 2. http://physedu.in/uploads/publication/11/201/29.3.2FDEs-in-physics-part-2.pdf.

[36] The formal curricula and lectures for the two courses are posted at http://ckraju.net/hps-aiu and http://ckraju.net/hps2-aiu/ . See also blog posts at http://ckraju.net/blog/?p=73, and http://ckraju.net/blog/?p=89.

[37] C. K. Raju, *Ending academic imperialism*,Multiversity and Citizens International, Penang, 2011. http://multiworldindia.org/wp-content/uploads/2010/05/ckr-Tehran-talk-on-academic-imperialism.pdf. Video at http://www.youtube.com/watch?v=zdvgH4gByfk.

[38] See part 5 of the video series, links to which are posted at http://tvmultiversity.blogspot.in/2014/02/c-k-raju-interviewed-by-claude-alvares.html.