Teach *ganita*, not formal math

Some suggestions regarding the Draft New Education Policy 2016

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Decolonise education to free the mind

Colonialism differed from a mere military conquest in that it captured the mind. This was achieved through "education". Macaulay's 1835 Minute on Education[1] is well known. What is hardly known is his speech of 1848 to British Parliament,[2] prescribing "education" for the British poor as the best antidote to the spectre of revolt which was then haunting Europe. Recall that all education in Britain, then, was a church monopoly, as it had been for centuries, and Macaulay understood that that church education was designed to capture the mind and tame it.[3]

After independence India should have decolonised its education system. Did the Macaulay doctrine of producing enslaved minds in awe of the West suit independent India? The question should at least have been seriously discussed, but no such discussion took place in the last 68 years. No concrete change was proposed even by the many who blamed Macaulay. The captured minds could imagine no change.

In contrast, a mere 20 years after independence, South African students woke up, and have forcefully demanded decolonisation of the education system through the #RhodesMustFall campaign. They understood what Steve Biko had said, that "the most potent weapon in the hands of the oppressor is the mind of the oppressed",[4] a mind shaped by education.

But the draft NEP 2016[5] is TOTALLY SILENT on the question of decolonisation of education. This continues the trend set by the first University Education Commission, which, in its 1949 report, just stated some homilies about the objectives of higher education. It never once mentioned that Western higher education system, which it continued, was designed and developed by the church. It tacitly assumed that the church, and Macaulay, were motivated by some altruistic and not political goals. The report just quoted the contemptuous statements of Macaulay and Ram Mohun Roy,[6] without seriously balancing them.

That contempt was deliberately inculcated by missionary schools, functioning in India since 1510, because instilling a sense of inferiority in one's own culture is a key milestone towards full conversion. Western universities too (starting from Bologna, and including Oxford and Cambridge) were church institutions set up and controlled wholly by the church as part of its Crusading plan to produce an army

1 T. B. Macaulay, 1835, Minute on Education. The Minute may be found online on many sites, such as http://www.languageinindia.com/april2003/macaulay.html.

2 T. B. Macaulay, Speech to the House of Commons, 18 April 1847. *Miscellaneous Writings and Speeches of Lord Macaulay*, vol. IV, Speeches of Lord Macaulay, http://www.gutenberg.org/files/2170/2170-h/2170-h.htm#2H_4_0031.

3 C. K .Raju, "Education and Church: Decolonising the hard sceinces", *Frontier Weekly* **46** (2013). http://frontierweekly.com/archive/vol-number/vol/vol-46-2013-14/46-7/46-7-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.

4 Steve Biko, *I Write What I Like*, ed. Aelred Stubbs, Heinemann, Oxford, 1987, p. 69.

5 Draft inputs to the New Education Policy, 2016, HRD Ministry.

6 Report of the University Education Commission, 1949, Ministry of Education, 1962, vol. 1.

of missionaries to supplement Europe's military weakness. Western higher education, designed to create a missionary mindset, inculcated total faith in the authority of the church/West, as in the current Wikipedia definition of "reliable source". This educational design was perfected over the seven centuries that Western higher education remained under total church control. But why do we need it?

The false history of science

Macaulay proclaimed that Western education was needed for science since the West was "immeasurably superior" as regards science. In fact, that claim of "superiority" was based on a false history of science.[7] But the resulting education system was successful in teaching us blind faith in Western authority; so successful that in two centuries no one even thought of independently cross-checking that bogus history of science. And, if that history is challenged today, the Western educated cling to those false myths as fiercely as a missionary clings to the belief in virgin birth. Unable to produce evidence, their stock tactic is to just denounce the critic.

For example, on that fake history, "Euclid" was declared the father of mathematics. I have been pointing out for over 15 years that "Euclid" is pure concoction. This upset people indoctrinated about "Euclid" from childhood, but they could produce no evidence. To drive home the absence of evidence for "Euclid", I instituted a challenge prize of Rs 2 lakhs for serious evidence about Euclid.[8] No one dared claim that prize, in the last five year but tales of "Euclid" still dishonestly persist in the school math texts, including those authored by a former Director of NCERT (Pervin Sinclair, who was directly informed[9]). They continue to indoctrinate children into a key Western myth.

There is no dearth of apologias. Just as theologians indefinitely defend their false claims, Western bhakts defend those false Western myths despite lack of evidence. A common tack is to say, they don't care about the person, "Euclid", but only about the book *Elements*, he supposedly wrote. These people just learnt myths, but obviously not their school math. Thus, it was admitted over a century ago, even in the West (for example by Bertrand Russell), that there are NO valid deductive proofs in the *Elements*.[10] The claim of "superior" deductive proofs in the *Elements* was fabricated by the church, which reinterpreted the book in support of its Crusading theology of reason (of Aquinas et al.), and the mass of Europeans just credulously believed it for centuries without applying their mind.[11]

The bad Western philosophy of formal math

When we teach formal math in our schools and universities today, we also advance that theological claim of rational theology that (metaphysical) deductive proofs are "superior" to empirical proofs. This inculcates contempt for ALL systems of Indian philosophy as "inferior" for they all accept empirical

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7 For a quick account, see, e.g., C. K. Raju, *Is Science Western in Origin?* Multiversity, Penang, and Daanish Books, Delhi 2009, reprint Other India Bookstore, Goa, 2014.

8 C. K. Raju, *Euclid and Jesus*, Multiversity, Penang, 2012. The prize was instituted much earlier. See, e.g., the video-talk "Decolonising history: Good Bye Euclid!", chaired by the Malaysian Deputy Minister of Higher Education, 2011. See links at http://ckraju.net/blog/?p=63.

9 C. K. Raju, "Towards Equity in Mathematics Education. 1: Good Bye Euclid!" Paper presented at ISSA Congress, SNDT University, Mumbai, Dec 2007 in presence of Sinclair. *Bharatiya Samajik Chintan* (New Series) **7** (4) (2009) pp. 255–264. http://ckraju.net/papers/MathEducation1Euclid.pdf. In 2008, Krishna Kumar sent the head of the NCERT math department to my symposium, where he asked "what is the need for primary sources, we go by the committee"!

10 Bertrand Russell, "It is nothing less than a scandal that he [Euclid] should still be taught to boys in England" in *Mysticism and Logic and other Essays,* George Allen and Unwin, London, 1917.

11 For details, see *Euclid and Jesus*, cited above.

proof (प्रत्यक्ष प्रमाण) as the first means of proof, as does science.[12] Doesn't that tacit teaching of contempt for all Indian systems need at least a public discussion? The counter-claim that deductive proofs are inferior since *more* fallible than empirical proofs has been suppressed by the simple tactic of evasion.

Thus, the *validity* of deductive proofs is not easily determined: for example, for 7 centuries, all the best minds in the West wrongly believed "Euclid's" *Elements* was a model of deductive proof, when even its very first proposition is proved empirically, not deduced from any axiom.[13]

Second, as Lokayat argued, even a valid deductive proof does not lead to valid knowledge: for the initial premises may be faulty. Even formalists admit that the theorems of formal math provide, at best, relative truths, relative to the postulates. Indeed, *any* proposition, absolutely any nonsense whatsoever, can be proved deductively as a theorem, starting from some postulates.[14] Such theorems are obviously NOT valid knowledge, for the validity of the inference depends on the validity of the postulates. But there is no way to empirically check the validity of the postulates of formal math (such as the postulates of axiomatic set theory) for those postulates are 100% metaphysics, and not refutable. This forces dependence on authority, and, in practice, we slavishly teach only those postulates approved by Western authority, e.g., Peano's axioms, or "real" numbers.

Third, "reason" rests on logic and formal math (like Western theology) naively assumed 2-valued logic. However, logic varies with culture (as in Buddhist logic of *catuskoti*, or Jain logic of *syadvada*), and with empirical facts (as in quantum logic).[15] And, even if a case for 2-valued logic is established on empirical grounds, that already knocks the bottom out of the claim that pure deductive proofs are "superior" to empirical proofs.

Ganita as decolonised math

A decolonised math would accept the empirical in math, as in Indian *ganita*. Second, students learn (and ought to be taught) math for its practically useful calculations, and NOT to learn the method of supposedly infallible deductive proof (for persuasion) which is just a church requirement.

The typical apologia of the Western bhakt is to ask, "that won't change 1+1=2 would it". Of course, it will. For example, children learn 1+1=2 using empirical referents. One apple and one apple make two apples. But at a higher level they are taught the Western philosophy of formal math, that the kindergarten way is wrong, since it is empirical, and the "superior" way is to use deductive proofs from some axioms. A purportedly "superior" deductive proof of 1+1=2 supplied by Whitehead and Russell

12 C. K. Raju, *Cultural Foundations of Mathematics*, Pearson Longman, 2007. Also, "Computers, Mathematics Education, and the Alternative Epistemology of the Calculus in the YuktiBhâsâ", *Philosophy East and West*, **51**:3 (2001) pp. 325–362. http://ckraju.net/papers/Hawaii.pdf.

13 For more details, see "Ganita vs math: ten myths underlying formal math and the need to reject them", talk at International conference on "Plurality in math" Kolkata, Dec 2015. http://ckraju.net/papers/ganita-vs-math.pdf. Also, video-talk at Indian Institute of Science, Bengaluru, "Calculus: ganita or mathematics", Video: https://youtu.be/U-r1CWU-KKM Presentation: http://ckraju.net/papers/presentations/iisc-r.pdf. For some newspaper-level articles, see "मैथेमैटिक्स और गणित में फर्क है", *Naidunia,* 25 May 2013, http://naiduniaepaper.jagran.com/Details.aspx?id=511188&boxid=28683834,

14 For a non-technical example, of how to deductively prove the theorem "Russell was a racist", see the interview: http://www.din.today/prof-c-k-raju-decolonizing-mathematics-leads-to-better-mathematics/

15 For a more detailed account, see article on "Logic", Encyclopedia of Non-Western Science, Technology, and Medicine, Springer, 2008, Also at, http://ckraju.net/papers/Nonwestern-logic.pdf.

in their *Principia,* took 368 pages! That complexity adds nothing to the *practical* value of 1+1=2. But it teaches blind faith: no one I know ever checked those 368 pages. Most are too ignorant to do so, and just believe on the strength of Russell's authority, for what the colonised learn is blind faith in the West. Nor do we need the equivalent complexities of Peano's axioms or set theory, which too bring in a particular (non-universal) metaphysics of infinity, tied to church dogmas about eternity[16] something which, leave aside our educational policy-makers, even a head of an IIT math department never understood.[17] Anyone who cannot publicly explain why 1+1=2 should be prohibited from making education policy.

The argument for decolonisation from the real history of math

That we must decolonise mathematics by rejecting formal math is a conclusion that also emerges from a truer historical perspective. Contrary to Macaulay's deceitful and conceitful boasts, historically speaking, most school math, arithmetic, algebra, trigonometry, calculus, and probability, developed in India as *ganita*, for its practical value. It was transmitted to the West also for its practical value: arithmetic for commerce, trigonometry for navigation, calculus for astronomy, and probability for games of chance. While the West grasped the practical value, it had enormous conceptual difficulties with the imported *ganita*. Since Western bhakts find that hard to swallow, here are some examples.

For example, Europeans failed to understand the efficient Indian arithmetic of elementary algorithms (basic methods for addition, subtraction, multiplication and division) so named after al Khwarizmi (Algorismus) through whose book *Hisab al Hind* Indian arithmetic first reached Christian Europe from Muslim Cordoba in the 10th c. Westerners failed to understand it because they were accustomed to arithmetic done in the primitive Greek and Roman way on an abacus. In 976, Gerbert (later Pope Sylvester II), the most learned Westerner of the times, who had written a tome on the abacus, wrongly equated arithmetic with the abacus. Hence, he got a special abacus (apices) constructed! That defeated the whole purpose of algorithms. He wrongly believed the efficiency of the imported arithmetic was due to some magic in the shape of the numbers, hence the foolish term “Arabic numerals”!

Later-day Florentine merchants again imported Indian algorithms (from Arabs via Africa), in the 12th c., for they recognized the competitive advantage of efficient arithmetic for commerce. But they were puzzled by the Indian decimal place-value system. This puzzlement is shown by the very word zero, which derives from *sifr* or cypher, meaning mysterious code. Europeans were accustomed to primitive Roman numerals which are additive, as in XII being the same as X + I + I. But 100 is not equal to 1+0+0 = 1. Hence, Florentines complained that zero has no value in itself but adds any amount of value to the preceding number! Hence, also, Florence passed the law against the mysterious zero that all financial contracts (cheques) must be written in words as well. This confusion about elementary arithmetic persisted in Europe for *at least* 600 years, until ca. 1572 when Clavius introduced “practical mathematics” in the Jesuit syllabus.

The same story is repeated in other cases. For example, the term “sine” is a howler from the Toledo mass translations of Arabic books (ca. 1125). The word “sine” derives from the Latin *sinus*, meaning fold, or pocket, from the Arabic *jaib* (जेब), a misreading of *jiba* from the Sanskrit *jiva*. In particular, the very word “trigonometry” involves a conceptual confusion, since what is being measured is the

16 C. K. Raju, “Eternity and Infinity: the Western misunderstanding of Indian mathematics and its consequences for science today.” *American Philosophical Association Newsletter on Asian and Asian American Philosophers and Philosophies* **14**(2) (2015) pp. 27-33. Draft at http://ckraju.net/papers/Eternity-and-infinity.pdf.

17 “IIT and set theory”, http://ckraju.net/blog/?p=44.

circle, not the triangle. The relation of sine to π is not incidental.

The story about the calculus and probability is similar. In this case, the Jesuits mass translated Indian texts in their Cochin-based college in the 16th c., with the help of local Syrian Christians, and sent the translations back to Europe. Europeans recognized the practical value of calculus in deriving precise trigonometric values, so critical to navigation, and their dreams of wealth, but they were conceptually confused by the Indian infinite series. In the 17th c., Descartes said that the ratio of straight and curved lines was beyond the human mind. A charitable interpretation would be that he was alluding to the infinite series for the number π. Galileo concurred and left "disreputable" calculus to his student Cavalieri. Newton rightly commented on Leibniz' lack of understanding of the Indian infinite series, today called Leibniz series, but Newton's own "fluxions" were atrociously confused and had to be abandoned. [18]

Eventually, what the West did was to add a wrapper of metaphysics to the imported Indian *ganita.* This was packaged with the usual false Western history and returned to India, as something "superior". Gullible Indians swallowed it all and think it sacrilege to question the story. Replacing formal math by *ganita* eliminates the added metaphysics but does not negatively affect the practical value. For example, to send a rocket to Mars, we still calculate the numerical solution of ordinary differential equations on a computer using numerical techniques similar to those invented by Aryabhata. This is true of all applications of national importance, which I surveyed for Indian's first supercomputer, Param. On the contrary, the Western metaphysics makes math inferior, as I have demonstrated: rejecting Newton's metaphysics of time (which he used to justify the calculus) leads to a better theory of gravitation.[19]

That is, the Western metaphysics in formal math is either irrelevant to the practical value of the original *ganita*, or else a hindrance, so we should revert to the teaching of *ganita*.

How can a decolonised curriculum be implemented?

Now the NEP 2016 talks vaguely of curricular reform. However, it does not say *who* will carry out the curricular reform or how: how exactly can decolonised curricula be constructed by relying on experts trained in "colonised" curricula? They usually have a vested interest in its continuation. The chief obstacle is not loss of practical value, in changing from math to *ganita*, but the missionary mindset of our indoctrinated Western-trained elite which has inculcated (a) widespread mathematical ignorance and an inability to decide things on one's own knowledge, (b) blind trust in the West and its certified "experts", and (c) distrust of, and superstitious fear of doing the slightest thing contrary to the West.

The only solution is a PUBLIC discussion where any conflicting or vested interests of "experts" are put on the table, not just their Western certificates of approval and indoctrination. A public discussion does not mean just inviting the public to participate and give suggestions: it means the "experts" must be accountable to people; they must PUBLICLY justify the curricular choices they make with reference to the benefits to the society. They must not be allowed to evade, as they have done for the last two decades, or talk only in private, where they can purvey all manners of gossip.

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18 For a more detailed account, see C. K. Raju, *Cultural Foundations of Mathematics*, Pearson Longman, 2007.

19 See, e.g., C. K. Raju, "Functional Differential Equations. 4: Retarded gravitation", *Physics Education* (India) **31**(2) April-June, 2015, http://www.physedu.in/uploads/publication/19/309/1-Functional-differential-equations-4-Retarded-gravitation-(2).pdf.

Some concrete examples of decolonised math curricula

Another typical claim is that there is no alternative (TINA). To counter this TINA, the following are some illustrative examples of concrete decolonised math syllabi supported by actual or proposed teaching experiments.[20]

1. **Calculus without limits.** This makes math easy,[21] and leads to better science both at the elementary level,[22] and advanced level.[23]

   Limits and formal real numbers are part of the elaborate Western metaphysics of the calculus. Students of science and engineering rightly don't see the point of any of this. But they have no choice. The teachers have no choice either to modify the centralised syllabus cast in concrete in the name of quality by ignorant policy makers who could also not correctly judge "experts" with vested interests. Anyway, that metaphysics is too complex to teach, hence even the usual fat college calculus texts of over thousand pages barely touch upon it, leaving it for advanced courses in analysis, which again leave out key details for further advanced courses etc.

   Reverting to the original numerical techniques of Aryabhata and the simple "non-Archimedean" arithmetic of Brahmagupta,[24] together with the philosophy of zeroism[25] makes calculus so easy that it can be taught in five days, with full understanding. Because it becomes easy, students can do real scientific problems left out as too hard in usual calculus courses. (Demonstrated cases include the exact motion of the simple pendulum, involving elliptic functions, and the brachistochrone with resistance.) This teaching experiment on "calculus without limits" has been successfully performed with 8 groups in 5 universities across 3 countries. The groups were varied: they included 1 batch of post-graduate math students, 1 batch of undergraduate pure math students, 1 batch of undergraduate applied math students, 1 batch of non-math students, 1 group of social scientists (Ambedkar University Delhi), one group of high-school level students

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20 There is a long series of articles, blogs, and news reports on this. See, e.g., CKR, "Decolonising math and science". In: *Decolonising the University*, ed. Claude Alvares and Shad Faruqi,USM and Citizens International, 2012, pp. 162–195. http://ckraju.net/papers/decolonisation-paper.pdf. "Decolonising math and science education". *Ghadar Jari Hai* **8**(3), 2014, pp. 5-12. http://www.ghadar.in/gjh_html/?q=content/decolonising-math-and-science-education. Also, similar talk at Delhi University International Seminar on education, to appear in Proc.

21 This happens because the superfluous metaphysics is eliminated. For popular newspaper accounts see "Mathematics? No Problem!", *New Strait Times*, Malaysia, 24 June 2011, http://ckraju.net/press/2011/NST-24-July-2011-pH1-H2-reduced.pdf. "गणित कठिन क्यों लगता है?", *Dainik Bhaskar*, 9 June 2012, http://ckraju.net/press/2012/ganita-kathin-kyon-lagata-hai.gif "Indian minds, alien calculations", *The Pioneer*, 9 July 2015, http://www.dailypioneer.com/columnists/oped/indian-minds-alien-calculations.html, etc.

22 For an account of how the elementary science of the simple pendulum is taught wrongly today, due to difficulties with math, see, C. K. Raju, "Time: what is it that it can be measured?" *Science & Education*, **15**(6) (2006) pp. 537–551. Draft available from http://ckraju.net/papers/ckr_pendu_1_paper.pdf. The exact time period of the simple pendulum, as easily measured cannot be correctly calculated. For an account of how the new teaching method results in a solution to the problem, see the school project on pendulum, posted at http://ckraju.net/11picsoftime/pendulum.pdf.

23 In addition to the issue of gravitation, mentioned earlier, there are various other issues, for which see my MIT talk (and references) "Calculus: the real story", Video: https://youtu.be/IaodCGDjqzs , Presentation: http://ckraju.net/papers/presentations/MIT.pdf , Abstract: http://ckraju.net/papers/Calculus-story-abstract.html , Blog: http://ckraju.net/blog/?p=106.

24 For quick details of non-Archimedean arithmetic in relation to Non-Standard Analysis, see my MIT talk, cited above.

25 See, e.g., my article "Zeroism", in the *Encyclopedia of Non-Western Science, Technology, and Medicine*, Springer, 2014, http://ckraju.net/papers/Springer/zeroism-springer-f.pdf. For an easier exposition, see the conversation with the Dalai Lama, Video: https://youtu.be/SkS1HM6g0O4, Presentation: http://ckraju.net/papers/presentations/Buddhism-and-science.pdf , News reports: *Sunday Guardian*: http://www.sundayguardianlive.com/opinion/4583-must-decolonise-scientific-education-progress etc.

(Central University of Tibetan Studies, Sarnath), etc. The post-test involved problems drawn at random from a published calculus question bank.[26]

The PG course touched upon the limitations of the university calculus with limits because of which one has to fall back on the theory of Schwartz distributions for applications to, say, quantum field theory or fluid dynamics, or general relativity. Almost all students were unfamiliar with these complications (as are most "experts") and also unfamiliar with the further complications that arise when products of Schwartz distributions are encountered in advanced applications. All these cases are handled smoothly with "non-Archimedean" arithmetic and zeroism. This way of handling the infinities also results in an improved version of Maxwell's equations[27] free from the infinities (runaway solutions) of the classical theory, as also my new theory of retarded gravity. Thus, calculus without limits leads to a better science at all levels from elementary to advanced.

Those policy-makers who talk endlessly of the need for innovation should have the courage to publicly enable this innovative reform in the usual calculus curriculum based on bad Western philosophy and false Western history.

2. **String geometry** (*sulba* geometry). The geometry of the *sulba sutra* used a flexible string (as did Egyptian cord geometry). This has the great advantage that the length of curved lines can be measured. That cannot be done with any instrument in the geometry box today used in school. The ability to measure the length of curved lines leads to **conceptual clarity** on the notion of angle which is the relative length of a circular arc, relative to the circumference (if measured in degrees) or relative to the radius (if measured in radians). But, today, the notion of angle is taught in a confused way, as something to do with two straight lines. The geometry box uses a protractor to measure angles, but explaining that the measure of an angle does not depend on the size of the protractor involves an essential property of the *circle*, that its circumference increases in proportion to its radius. But this property is not meaningful without a way to measure the length of the circumference of the circle, which is a curved line. Today, defining the circumference of a circle inevitably brings in the metaphysics of infinity. Teaching geometry in the *sulba sutra* way avoids this metaphysics, and also leads to an easier understanding of calculus at a later stage.

   The simple, local, low-cost and eco-friendly string can replace the entire geometry box.[28] It has immediate practical applications which make sense in rural areas: cord geometry was used since the Rhind Papyrus to measure the area of agricultural fields, impossible with the compass box. Teaching experiments have been proposed.

   The *sulba sutra* also reformulates the "Pythagorean theorem" in a way that is truly superior to the rudimentary formulation found in the *Elements,* and also needed for its practical applications. (The *sulba sutra*-s were practical manuals for masons. Similar formulations

26 C. K. Raju, "Teaching mathematics with a different philosophy. Part 1: Formal mathematics as biased metaphysics." *Science and Culture* **77** (7-8) (2011) pp. 274–279. http://www.scienceandculture-isna.org/July-aug-2011/03%20C%20K%20Raju.pdf, arxiv:1312.2099. Part 2: Calculus without limits", *Science and Culture* **77** (7-8) (2011) pp. 280–85. http://www.scienceandculture-isna.org/July-aug-2011/04%20C%20K%20Raju2.pdf. arxiv:1312.2100. "Calculus without limits", Proc. Second People's Education Congress, Homi Bhabha Centre, Mumbai, http://ckraju.net/papers/calculus-without-limits-paper-2pce.pdf.

27 "Functional differential equations. 3: Radiative damping", *Physics Education* (India), **30**(3), July-Sep 2014, Article 8. http://www.physedu.in/uploads/publication/15/263/7.-Functional-differential-equations.pdf.

28 "Towards Equity in Math Education 2. The Indian Rope Trick" *Bharatiya Samajik Chintan* **7** (4) (2009) 265–269.

existed in Iraq and Egypt, but the detailed documentation survives only in India.) In particular, the Manava *sulba sutra* (10.10) is unique in stating the "Pythagorean theorem" using square *roots* (of the sum of squares) as required for its practical applications.

Recall that calculating square roots is impossible with Greek and Roman numerals (despite tall speculative claims about Archimedes based on 16th c. Latin translations of Byzantine Greek manuscripts). Recall also that the algorithm for extracting square roots (as found in *Aryabhatiya*[29]) went to Europe from India, via Latin translations of al Khwarizmi's *Hisab al Hind*. Recall further that this is indicated by the very term "surd" (for $\sqrt{2}$) which is another translation howler from 12th c. Toledo. The term from the Latin *surdus* means deaf. Why is $\sqrt{2}$ deaf? Recall that the "Pythagorean theorem is stated in terms of a *rectangle* and its *diagonal* in all ancient texts, tablets and papyri. Recall further that $\sqrt{2}$ was understood as the diagonal of the unit square. But the Sanskrit word for "diagonal" (*karna*) also means "ear". Thus, the term bad *karna* (meaning "bad diagonal") was wrongly translated as "bad ear", hence deaf ! Today, we teach this foolish Western terminology to our children without even a smile.

Recall, further, that the understanding of $\sqrt{2}$ as *in*exact (सविशेष)[30] and *non*-eternal (अनित्य)[31] in the *sulba sutra*-s raises an important philosophical issue about the fallibility of mathematics wrongly regarded as *eternal* and *exact* truth in the West, due to religious beliefs since Plato. In the story of Socrates and the slave boy in Plato's *Meno*, Socrates claims that by demonstrating the slave boy's innate knowledge of geometry, he has proved the existence of the soul.[32] This linkage of mathematics to the soul is confirmed by Proclus[33] who too derives "mathematics" from mathesis, meaning learning, in accord with the Platonic doctrine that "all learning is recollection" (of the eternal ideas in the soul).

In contrast what is currently taught today in schools is a weird mixture of two **incompatible** types of geometry. The first is Hilbert's synthetic geometry[34] and the second is compass-box geometry. Why?

Hilbert tried to "save the story" of deductive proofs in "Euclid's" *Elements* by proposing the fantastic hypothesis that the book concerned **"synthetic geometry"**. This is **"geometry" without the "metry"** for it does NOT allow any length measurement but yet allows area measurement! This fantastic hypothesis was advanced to justify the apparent prolixity of the *Elements*. The hallmark of synthetic geometry is the use of Hilbert's synthetic term "congruence" instead of the metric term "equality" in the original *Elements*. Its other hallmark concerns proposition 4 of the original *Elements* (side angle side proposition, that two triangles are equal if two sides and included angle are equal). That proposition, originally proved empirically, is changed from a theorem to a postulate, the SAS postulate. Both these hallmarks are found in our current school texts.

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29 गणित, 4.

30 Baudhayana *sulba sutra* 2.12

31 Apastamaba *sulba sutra*, 3.2

32 Plato, *Meno*, in Dialogues of Plato, trans. B. Jowett, Encyclopaedia Britannica, Chicago, 1996.

33 Proclus, *Commentary,* 47, trans. Glenn R. Morrow, Princeton University Press, Princeton, 1992, p. 38.

34 For a table comparing various types of geometry, see *Cultural Foundations of Mathematics*, cited above, chp. 1, "Euclid and Hilbert". For another account see E. Moise, *Elementary Geometry from an Advanced Standpoint*, Addison Wesley, Reading Mass, 1968.

Neither school teachers nor students see the point of any of this, and synthetic geometry is pure metaphysics, and does not at all concern the real world. But teachers are forced to teach it, and students are forced to learn it, because our ignorant educational policy-makers force a centralized syllabus on them, which just consists of blind imitation of the West. When the Yale School Mathematics Study Group[35] recommended that synthetic geometry should be taught we slavishly accepted that recommendation, around 1970, without the slightest discussion.

This is another important example of how the centralization of the math syllabus, as wrongly recommended by NEP 2016, is directly responsible for poor quality of education, and does not allow students or teachers to question or correct a bad syllabus. The ignorant policy-makers just went by the wrong story that "math is universal"; they could not correctly assess the knowledge or vested interests of the "experts" they employed, and they blocked all dissent and questioning at the ground level which could have acted as a check on their ignorance. We should instead have deleted all reference to "Euclid" from our texts.

As already stated, the compass-box is deficient, since it has no instrument to measure the length of curved lines (hence no way to calculate the correct size of the earth, as was routinely done in India, a thousand years or more before Columbus badly failed to do so[36]). In short, compass-box geometry is geometry without the "geo", so to say! So what we teach today is a weird mixture of "geometry without the metry" (synthetic geometry) plus "geometry without the geo" (compass-box geometry), together with a bad doctrine of "superior" deductive proofs, which can actually be used to prove any nonsense on the strength of authority. Instead of this hopelessly bad way of teaching geometry we should simply revert to string geometry (geometry of the *sulba sutra*), use of the empirical in math, and the philosophy that mathematical calculations are approximate. At the very least we should allow room for such educational innovation at the ground level.

3. **History and Philosophy of Science**. As already pointed out, Macaulay effected a change in the educational system by appealing to a false history of science, swallowed without any verification by the pathetically credulous colonised mind. Therefore, as I argued in *Ending Academic Imperialism*, the first step towards decolonisation must be to undo that false history of science which is supported by and propagates a bad philosophy of math. After a week-long international workshop in AlBukhary International University, Malaysia, a new course was formulated and successfully taught by me. Because of a demand from students, a second part to the course was added. The syllabus, as well as the reactions of the students interviewed by Claude Alvares[37] is posted online. It is important that these courses should be taught at the level of the university, and select content from them introduced into school education, to offset Wikipedia propaganda.

4. **Statistics for Social Science**. It should be recalled that probability too first developed in ancient India.[38] The game of dice itself is described in the *aksa sukta* of the Rgveda (10.2.34). Dice are

35 School Mathematics Study Group, *Geometry*, Yale University Press, 1961.

36 Compared to the estimates of Aryabhata and Brahmagupta, or al Biruni, Columbus was off by 40%, so that Portugal passed a law in 1501 banning the carrying of globes on board ships. See, *Cultural Foundations of Mathematics*, cited above.

37 A 2:30 sec video of this is posted at http://youtu.be/ozQRBNk2alg. The course materials are posted at http://ckraju.net/hps-aiu, and http://ckraju.net/hps2-aiu/

38 "Probability in Ancient India", chp. 37 in *Handbook of the Philosophy of Science*, vol 7. *Philosophy of Statistics*, ed, Dov M. Gabbay, Paul Thagard and John Woods. Elsevier, 2011, pp. 1175-1196. http://www.ckraju.net/papers/Probability-in-Ancient-India.pdf.

juxtaposed with sampling theory in the *Mahabharata* story of Nala and Damayanti. There is definitely a notion of fair/unfair game of dice in the *Mahabharata,* corresponding to a notion of probability. The theory of permutations and combinations also developed in India starting from the -3rd c. Pingala's *Chandahsutra*, and his 10th c. commentator Halayudha who gave the *meru prastara* today wrongly known as "Pascal's triangle".

Further it should be recalled that the metaphysics of limits used for the calculus does NOT work in the case of probability. All practical applications of sampling theory are based on relative frequency. However, the frequentist interpretation fails, for probability cannot be defined as the "limit" of relative frequency except when the limit is understood in a probabilistic sense. Thus, any such definition of probability (as the limit of relative frequency) ends up being circular. The traditional Indian way of doing probability as *ganita* (together with zeroism, and discarding of small numbers) does, however, work, and enables probability and statistics to be taught without teaching measure theory or the Lebesgue integral. This makes it very suitable for teaching it to social scientists to begin with.

Concluding recommendations

The above examples of decolonised syllabi are illustrative not exhaustive. Science too is not universal. For example, the first lesson in science today teaches "Newton's laws". The belief in "laws of nature" is not a scientific belief, it is a religious dogma first put forward by Aquinas that God rules the world with laws of nature. In any case, math is an essential input to science, so changing math changes science. Correcting Newton's metaphysics of the calculus leads to a different theory of gravitation and so on. A decolonised curriculum has been proposed also for physics,[39] and ethics.[40] Of course, many such decolonised courses have been proposed in social sciences, but the point of these suggestions was to tackle "hard" science used in Macaulay's argument, and still used to argue that Western education is indispensable for science and technology. At least let us make a beginning with math as *ganita*.

The key issue is how can such a reformed and decolonised curricula be actually brought into the education system? Colonial education has been perpetuated by decision makers who were all colonially educated. A key way to check such bad decision-making is to ask the decision-makers to publicly justify the choices they make. (It is NOT enough just to invite suggestions from the public, and to deal with them privately in any which way.)

A public discussion of the colonial education system should at least be carried out today, so many years after independence. Even a discussion is perceived as a big threat: this became manifest in the way church supporters in Malaysia attacked the very idea of holding a conference to think of ways to decolonise the university.[41] Church supporters persistently denounced the meeting, in broad generic

39 See, e.g., "Decolonisation of education: further steps", paper for the meeting on "Decolonisation and leadership", Nottingham University, Malaysia Campus, Jan 2015. To appear in Proc. Draft posted at http://ckraju.net/papers/KL-abstract-and-draft.pdf. For details of the physics syllabus, see the recent series of articles on Functional Differential Equations in *Physics Education*. These are all referred to in the last article "Functional Differential Equations. 6: Quantum mechanics", *Physics Education* (India) **32**(1) Jan-March, 2016. http://www.physedu.in/uploads/publication/22/369/11-FDEs-in-physics-6-(1).pdf.

40 As regards ethics, the underlying ethic is explained in "The Harmony principle", in *Philosophy East and West*, **63** (4) 2013, pp. 586-604. http://www.ckraju.net/papers/Harmony-principle-pew.pdf. A similar paper with the same title also in an edited volume *Svaraj and samvad*, ed. Shail Mayaram, Sage, 2013.

41 See, e.g., *New Strait Times*, Malaysia, 17 July 2011, archived at http://ckraju.net/press/2011/NST-17-July-2011-pH1-H3-reduced.pdf.

terms, without once engaging with any particulars discussed during the meeting.[42] A Western commentator too did exactly the same thing. My rebuttal was eventually published[43] but only with a mile-long editorial preface showing the embarrassment caused by the idea of allowing "natives" to respond.

Trolling is not the only way used to defend colonial education today. The church continues to work in sly ways. For example, Cambridge University awarded a PhD in the Philosophy of Science to a missionary who trained only in divinities, at the Singapore Bible College, and had nil knowledge of science. Armed with that degree, he then launched a course in the Philosophy of Science in the Universiti Sains Malaysia. The course effectively turned the classroom into a pulpit by using the Philosophy of Science as a label to spread church dogmas (about "laws of nature" and "causality" etc.). A public discussion did serve to expose him[44] (but such is the awe in which the colonised mind holds Cambridge that many senior managers lacked the spine to stand up).

A special session at the 38th ISSA was announced to publicly debate the philosophy of mathematics.[45] Formal mathematicians, however, have persistently refused such a public debate—they know their case is weak, and their jobs are threatened. A taboo (or evasion) is the only way to ensure the persistence of formal math. Besides, private backdoor gossip is an easy way to sway decision-makers, especially to maintain status quo! However, a top Indian formal mathematician did participate in the meeting. The minutes of the ensuing conversation with him are also publicly posted.[46]

In the same spirit of public discussion, the suggestion is NOT to use state authority to immediately impose the decolonised curricula. Instead state authority must first be used to enforce *accountability of formal mathematicians* to ordinary people, to force them to publicly justify why they teach what they teach. (And if the mathematics they teach is primarily for some purported aesthetics, then formal mathematics must not be funded by science and technology departments of the government,[47] and should not be taught in science and technology courses.) Lack of accountability (to people, not merely to peers) breeds academic corruption which is far more dangerous than financial corruption.

A state push is, of course, necessary for decolonisation, but the further suggestion is that even after decolonised courses are implemented, the doors for dialogue and debate must remain open. Thus, the policy makers (a) must create a forum where decolonised curricula can be publicly discussed on a continuous (say quarterly or semi-annual basis), and (b) provide ample room for independent experimentation with decolonised curricula, both at school and university level. When the students take up the decolonised curriculum they should be enthusiastic. A stable curriculum may take perhaps 30 years to develop fully, but at least let the process begin with such decolonised courses as already exist.

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42 See, for example, the 36 clips from *The Sun*, Malaysia, archived at "Decolonisation: Conversations in the Sun" http://ckraju.net/blog/?p=61.

43 "Decolonising our universities: time for change." Response to Wildavsky. GlobalHigherEd http://globalhighered.wordpress.com/2011/09/11/decolonising-our-universities-time-for-change/.

44 The minutes of the discussion are publicly posted at http://ckraju.net/usm/PSc-minutes.html.

45 This was posted on various lists. http://ckraju.net/issa/call-for-participation-issa-special-session.html.

46 http://ckraju.net/issa/conversation-draft-minutes.html.

47 See, further, C. K. Raju, "Kosambi the mathematician", Special article, *Economic and Political Weekly* **44** (20)May16–22 (2009) pp. 33–45. http://ckraju.net/papers/Kosambi-EPW.pdf.