Draft extended summary with references for panelists

Three ways to decolonise science

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Decolonising the science curriculum poses a special challenge, for it is believed that science is objective and universal. It is important to understand why this is NOT true, and why proceeding on this belief will result in a very superficial decolonisation of the science curriculum in a way which regards decolonisation as merely a matter of pedagogy, and unconnected with the *content* of science. In this talk I will also explain *how to* decolonise science, and will provide concrete examples of decolonised science.

Summarily, the three methods are as follows.

1. **Decolonise the method of validating science.** Experiment is the right method of validating science. We should use Popper's criterion of refutability, and NOT rePutability (or publication in "reputed" journals) currently used as the *de facto* method of validating science. Secrecy (as in secretive peer review) has no place in science. Trust in social reputation has no place in science, for society is no utopia, and very reputed persons may be dishonest. Using such criteria effectively redefines science as anything authoritatively approved by the West. This redefinition needs to be rejected.[1] Else no decolonised science is possible, for the West will rush to reject decolonised science or anything which challenges its authority.

2. **Decolonise the history and philosophy of science.** On the stock history of science, science developed in the West, first with the Greeks, then in post-renaissance Europe. This story is almost wholly false, and I have detailed four key examples: Euclid and Claudius Ptolemy, and the Copernican and Newtonian revolution.[2]

   The story of Greek origins of science, first concocted by the Crusading church, was picked up by racist historians. The thesis of racist appropriation argued by George James, Diop, Martin Bernal, and Molefi Asante, applies also to science: this false history of Greek origins of science was used also to appropriate black Egyptian scientific knowledge.

   There are no primary Greek sources (such as the Rhind papyrus, or Iraqi clay tablets), nor any continuous chain of intermediate sources (a chain of commentators each quoting the full original, as in India) to connect a late text to its origins. Hence, the repeated use of authority, as a pitiful substitute for evidence, is particularly manifest in e.g. Lefkowitz's *Not Out of Africa*.[3] There is robust non-textual counter-evidence that the Greeks and Romans were backward in

1 C. K. Raju, *Ending Academic Imperialism*, Multiversity, Penang, 2011. http://multiworldindia.org/wp-content/uploads/2010/05/Academic-imperialism-final.pdf.

2 C. K. Raju, *Is Science Western in Origin?* Multiversity, Penang, and Daanish Books, Delhi 2009, 2014. Reprint 2014, Other India Bookstore, Mapusa. Summary at http://ckraju.net/books/Is-Science-Western-in-Origin.html. Whole book at http://dl.dropbox.com/u/6179856/CK%20Raju%20with%20covers.pdf.

3 See the abstract and series of recent lectures at UNISA on the history and philosophy of science, http://ckraju.net/unisa.

science: for example, they could not maintain the calendar they learnt from Egypt.

Because of the absence of evidence, and the presence of counter evidence, my challenge prize (ZAR 40,000) for serious (primary) evidence for Euclid stands unclaimed for so many years.[4] Nevertheless, this false history continues in current school texts, to indoctrinate the minds of unsuspecting children. The glorification of a fake Euclid is used to mask the demand to imitate the church theology of reason: this has serious consequences for the content of math. **This false history is used to foist a bad philosophy of formal math different from the normal math.**

3. **Decolonise the philosophy of math.** Science is based on math. Hence, changing the way of doing math changes science. What is taught today is formal math (from class 6 onward). Formal math is NOT universal; it arose in the 20th c., and differs from the normal math which prevailed for thousands of years earlier.[5] Formal math prohibits the empirical; it is 100% metaphysics.[6] Thus, the use of formal math for science allows any convenient metaphysics to be smuggled into science on the strength of authority. **Decolonising math to eliminate this smuggled metaphysics, leads to a decolonised science, which is a better science.** I give three examples.

3.1 **Gravitation.** The first example concerns Newtonian physics. Newtonian physics is formulated using ordinary differential equations which requires the calculus. The understanding of calculus, as taught in the university today, involves a biased metaphysics[7] of infinity (formal real numbers) aligned to the post-Nicene church metaphysics of eternity ("linear" time).[8] This metaphysics was globalised by colonial education, but is decidedly *not* universal.

Actually, calculus developed in India as normal math (*ganit*) from the 5th c. onward using difference equations to calculate precise trigonometric values. Over a thousand year period this led to infinite series, summed with a different philosophy, again for the practical purpose of calculating accurate values of sine, arctangent, and π (accurate to 9 and 11 decimal places respectively). These were needed for the two key means of wealth in India, monsoon driven agriculture (which needed a good calendar, hence accurate astronomy) and overseas trade (which needed accurate techniques of celestial navigation).[9]

These accurate trigonometric values and related astronomical models were also badly needed by Europeans for the (specifically) European navigational problem. This was the chief scientific problem of Europe from the 15th to the 18th c., since overseas "trade" (or piracy) was then the basis of European dreams of wealth. Hence, in the usual way of stealing knowledge from others, and declaring it their own, in the 16th c. this knowledge of math and astronomy was

4 C. K. Raju, *Euclid and Jesus: How and why the church changed mathematics and Christianity across two religious wars,* Multiversity and Citizens International, Penang, 2012.

5 For a quick exposition of the difference between formal and normal math, see, C. K. Raju, "Mathematics, decolonization and censorship", https://kafila.online/2017/06/25/mathematics-and-censorship-c-k-raju/

6 E.g. C. K. Raju, "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.

7 See, e.g., 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.

8 See, e.g., the summary of my recent Berlin talk on "Decolonising time: time at the interface of science and religion", http://ckraju.net/papers/Berlin-time-abstract.html. Or see the video, https://www.youtube.com/watch?v=jltPVAkOVLg.

9 C. K. Raju, *Cultural Foundations of Mathematics: the nature of mathematical proof, and the transmission of the calculus from India to Europe in the 16th c. CE* (Pearson Longman, 2007 , PHISPC Vol. X.4, 477+xlv pp, ISBN: 81-317-0871-3. Summary at http://ckraju.net/papers/GJH-book-review.pdf.

stolen by Jesuits (who replicated the Toledo model of mass-translation in their Cochin college, ca. 1550 onward). The translated Indian texts went to Europe, where their content suddenly started appearing in the works of Mercator (precise secant values needed for his chart), Clavius (calendar, sine tables), Tycho Brahe ("Tychonic" model), Kepler (planetary observations), Galileo, his student Cavalieri, Fermat (challenge problem to European mathematicians, a solved exercise in an Indian text from 4 centuries earlier), Pascal (also probability, and permutations and combinations, and "Pascal's triangle" from Indian texts from a thousand years earlier), and then through Gregory, to Newton (infinite sine series, from 3 centuries earlier), and Leibniz ("Leibniz" series, from 3 centuries earlier).

The glorification of Newton and Leibniz as originators of the calculus suppresses the reality that mathematically challenged Europeans in the 17th c. did not *understand* the Indian method of summing infinite series using "non-Archimedean" arithmetic (avyakt ganit) and zeroism (sunyavada),[10] just as arithmetically challenged Europeans had earlier failed to understand, for centuries, the elementary Indian arithmetic of algorithms when they first imported it in the 10th c., or zero, when they again imported Indian arithmetic in the 12th c. through Florentine merchants.[11] Descartes declared infinite sums beyond the human mind, and Newton struggled to understand calculus using "fluxions", and his confused metaphysical doctrine of flowing time.[12]

It was exactly his *conceptual* error of making time metaphysical which led eventually to the failure of Newtonian physics a century ago.[13] While this has long been known, it has only recently been understood that Newton made time metaphysical just because of his conceptual difficulties in understanding calculus.[14]

Recall that Newton's "laws" of motion and Newton's "law" of gravitation are not independently refutable, hence come as a package deal. Therefore, correcting Newton's "laws" of motion forces us to correct Newtonian gravitation. The minimal correction is not general relativity but to make gravitation Lorentz covariant as in my retarded gravitation theory, necessarily based on functional (delay) differential equations.[15] It is impossible for a Lorentz-covariant force to be purely position dependent. Hence, the gravitational force must depend upon velocity. An easily refutable consequence is that the rotation of the earth must slightly affect the motion of nearby satellites and spacecraft, as observed in the NASA flyby anomaly, and as can be further experimentally tested.

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10 See the expository articles in the *Encyclopedia of Non-Western Science, Technology, and Medicine*, ed. H. Selin, Springer, Dordrecht, 2016. "Calculus" (http://ckraju.net/papers/Springer/ckr-Springer-encyclopedia-calculus-1-final.pdf). pp. 1010-1015. "Calculus transmission" (http://ckraju.net/papers/Springer/ckr-Springer-encyclopedia-calculus-2-final.pdf). pp. 1016-1022. "Zeroism" (http://ckraju.net/papers/Springer/zeroism-springer-f.pdf). pp. 4604-4610.

11 See, e.g., my talk at MIT. Abstract: http://ckraju.net/papers/Calculus-story-abstract.html. Video: https://youtu.be/IaodCGDjqzs.

12 *Cultural Foundations of Mathematics*, cited above.

13 C. K. Raju, *Time: Towards a Consistent Theory*, Kluwer Academic, Dordrecht, 1994. Also, "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.

14 C. K. Raju, "Retarded gravitation theory" in: Waldyr Rodrigues Jr, Richard Kerner, Gentil O. Pires, and Carlos Pinheiro (ed.), *Sixth International School on Field Theory and Gravitation*, American Institute of Physics, New York, 2012, pp. 260-276. http://ckraju.net/papers/retarded_gravitation_theory-rio.pdf.

15 "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.

3.2 **Stephen Hawking and singularities.** As a second example, of how the metaphysics of math is smuggled into science, I briefly indicate how the metaphysics of university calculus is used in the irrefutable singularity theory of Stephen Hawking. His chronology condition is directly aligned to Augustine's theology of time,[16] and slips in the church metaphysics of creationism into science. (The first creationist controversy was over cosmology, in the 6th c., not over Darwinian evolution.) I also briefly explain how the apparent breakdown of the differential equations of physics at a singularity is due to the limitations of university calculus, and can be easily avoided, even within general relativity, by reverting to the philosophy with which calculus originally developed.[17] This, is technical, and would be taken up in more detail in my lecture on decolonising math.

3.3 **Mechanistic "laws" of nature.** As a third example, another metaphysics which crept into Newtonian physics is the belief in "laws" of nature. The very term Newton's "laws" tells us to believe in this dogma of "laws of nature" first stated by Aquinas in *Summa Theologica*.[18] Indians used calculus for astronomy, but regarded it as only a fallible mathematical model, and had no grandiose delusions that it was universal and eternal. Mechanistic physics based on this dogma is trivially refuted by everyday observation of the creativity of living organisms, observations repeated thousands of times each day by billions of people. The failure of mechanistic physics to predict that observed behaviour must be discussed as physics, and without permitting the slightest reference to centuries of prolix theological discussions of "free will". (Else it must be admitted that current physics cannot be done without the support of that theological discourse.)[19] I briefly touch upon my proposal for a non-mechanistic physics, by discarding the other dogma of perfect causality, and admitting a tilt in the arrow of time.[20]

These three techniques act together. bad methods of validation can be used to preserve bad science. The same abuse of authority is used also to preserve a false history and bad philosophy, by censoring[21] any challenges to it.

4. Recommendations

This shows that, to decolonise the science curriculum we need to do the following.

1. **Teach students that science is about refutability** and NOT rePutability. Teach them how rePutability has repeatedly failed. Teach them also the ethics of science. This can

16 C. K. Raju, *The Eleven Pictures of Time*, Sage, 2003.

17 This was earlier done using non-standard analysis together with Schwartz distributions. However, the use of "non-Archimedean" arithmetic is enough. "Distributional matter tensors in relativity", *Proceedings of the Fifth Marcel Grossman meeting on General Relativity*, D. Blair and M. J. Buckingham (ed), R. Ruffini (series ed.), World Scientific, Singapore, 1989, pp. 421–23. arxiv: 0804.1998.

18 "Islam and Science", Keynote address at International Conference on Islam and Multiculturalism, Univ. of Malaya. In *Islam and Multiculturalism: Islam, Modern Science, and Technology*, ed. Asia-Europe Institute, University of Malaya, and Organization for Islamic Area Studies, Waseda University, Japan, 2013, pp. 1-14. http://ckraju.net/hps-aiu/Islam-and-Science-kl-paper.pdf.

19 C. K. Raju, "Time travel and the reality of spontaneity", *Found. Phys.*, **36**(7) 2006, pp. 1099-1113. Also, "Functional Differential Equations. 5: Time travel and life", *Physics Education* (India) **31**(4) Oct-Dec, 2015. http://www.physedu.in/uploads/publication/21/344/1.-Functional-differential-equations-5-Time-travel-and-life.pdf.

20 *Time: Towards a Consistent Theory*, cited above. A recent pedagogical account is in FDEs 5 cited above, and "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.

21 "Black thoughts matter: decolonized math, academic censorship, and the 'Pythagorean' proposition", *Journal of Black Studies* **48**(3) April 2017, pp. 256-278. http://journals.sagepub.com/doi/abs/10.1177/0021934716688311.

be included in the following.

2. **Have a full-fledged course in a critical history and philosophy of science,** which debunks all Western myths (such as "Euclid" or Archimedes) for which there is no evidence, as also myths like those of Copernicus and Newton, acknowledging the truth (that Copernicus copied from Ibn Shatir, and Newton used the Indian calculus).

   A key element of the course should be to teach the unreliability of tertiary sources like Wikipedia in history. Students should be taught to go solely by evidence, and to distrust the Lefkowitz sort of history which palms off Western authority for evidence.

   This course could be designed afresh or along the lines of such a course on history and philosophy of science repeatedly taught at Albukhary University, Malaysia, and being taught at universities in Delhi. A key issue in such a course in Africa would naturally be the issue of Egyptian achievements vis-a-vis Greeks, as in George James, Cheikh Anta Diop, Martin Bernal etc. and their detractors, with a focus on math and science, as in my UNISA lectures of "Not out of Greece".

3. **The decolonisation of the science curriculum must be preceded by the decolonisation of the math curriculum**. The aim should be to teach normal math, not the inferior and impractical metaphysics of formal math passed off using myths. **Texts already exist to teach cord geometry at the school level**, as an alternative to "Euclid". Those university students who have not learnt it could add it as a bridge course, along with **a course on calculus without limits** which latter has been repeatedly taught,[22] and is currently being taught as a regular course for engineering students at SGT University, Delhi. The great advantage of these courses is that they make math very easy, hence enable students to solve much harder problems not covered in usual calculus courses. They also lead to better science as explained above, by eliminating the junk metaphysics in formal math.

4. This could be followed by a course on decolonised statistics and data science, and decolonised physics.[23]

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22 C. K. Raju, "Teaching mathematics with a different philosophy. 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. Also, "Calculus without limits" article for Second People's Congress on Education, Homi Bhabha Centre for Science Education, Mumbai, 2009, in Proc. http://ckraju.net/papers/calculus-without-limits-paper-2pce.pdf.

23 C. K. Raju, "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. See, also, "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. Further. "Decolonising our universities: time for change." Response to Wildavsky. GlobalHigherEd http://globalhighered.wordpress.com/2011/09/11/decolonising-our-universities-time-for-change/. And, "Decolonisation of education: further steps", paper for the meeting on "Decolonisation and leadership", Nottingham University, Malaysia Campus, Jan 2015. Draft posted at http://ckraju.net/papers/KL-abstract-and-draft.pdf.