

Decolonising Math and Science Education

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Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Introduction

- ▶ Some confusion about the title

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Some confusion about the title
- ▶ “Calculus: the real story” a talk I gave at MIT in 2015

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Some confusion about the title
- ▶ “Calculus: the real story” a talk I gave at MIT in 2015
- ▶ against the MIT MOOC on calculus.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Some confusion about the title
- ▶ “Calculus: the real story” a talk I gave at MIT in 2015
- ▶ against the MIT MOOC on calculus.
- ▶ Watch the video (Google: “c k raju mit”).

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Some confusion about the title
- ▶ “Calculus: the real story” a talk I gave at MIT in 2015
- ▶ against the MIT MOOC on calculus.
- ▶ Watch the video (Google: “c k raju mit”).
- ▶ **This** talk will include calculus, but is broader in scope:

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Some confusion about the title
- ▶ “Calculus: the real story” a talk I gave at MIT in 2015
- ▶ against the MIT MOOC on calculus.
- ▶ Watch the video (Google: “c k raju mit”).
- ▶ **This** talk will include calculus, but is broader in scope:
- ▶ decolonising math and science.

The stock belief

- ▶ Generally believed that math and science are **universal** and objective,

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

The stock belief

- ▶ Generally believed that math and science are **universal** and objective,
- ▶ hence, cannot be decolonised.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

The stock belief

- ▶ Generally believed that math and science are **universal** and objective,
- ▶ hence, cannot be decolonised.
- ▶ Colonial education justified by Macaulay on the grounds that the colonised needed it for science

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

The stock belief

- ▶ Generally believed that math and science are **universal** and objective,
- ▶ hence, cannot be decolonised.
- ▶ Colonial education justified by Macaulay on the grounds that the colonised needed it for science
- ▶ As believed to this day. **But**

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

My thesis

- ▶ Math is **NOT** universal.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

My thesis

- ▶ Math is **NOT** universal.
- ▶ What is taught today in the university is **formal math**,

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

My thesis

- ▶ Math is **NOT** universal.
- ▶ What is taught today in the university is **formal math**,
- ▶ which began in the 20th c. with Bertrand Russell and David Hilbert.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Math is **NOT** universal.
- ▶ What is taught today in the university is **formal math**,
- ▶ which began in the 20th c. with Bertrand Russell and David Hilbert.
- ▶ The math which prevailed earlier (since the days of the Rhind papyrus) was **normal math**

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ If math is universal, let us select the universal math

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ If math is universal, let us select the universal math
- ▶ of the colonised which prevailed earlier!

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ If math is universal, let us select the universal math
- ▶ of the colonised which prevailed earlier!
- ▶ End of story!

Two types of math

- ▶ If, on the other hand, math is **not** universal, then

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Two types of math

- ▶ If, on the other hand, math is **not** universal, then
- ▶ there are at least two types of math:

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Two types of math

- ▶ If, on the other hand, math is **not** universal, then
- ▶ there are at least two types of math:
- ▶ formal math

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

Two types of math

- ▶ If, on the other hand, math is **not** universal, then
- ▶ there are at least two types of math:
- ▶ formal math
- ▶ and normal math (or the math of the colonised)

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Two types of math

- ▶ If, on the other hand, math is **not** universal, then
- ▶ there are at least two types of math:
- ▶ formal math
- ▶ and normal math (or the math of the colonised)
- ▶ (still taught in primary school).

Two types of math

- ▶ If, on the other hand, math is **not** universal, then
- ▶ there are at least two types of math:
 - ▶ formal math
 - ▶ and normal math (or the math of the colonised)
 - ▶ (still taught in primary school).
 - ▶ Science uses math: changing math changes science.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Teaching formal math justified by asserting that normal math is inferior.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Teaching formal math justified by asserting that normal math is inferior.
- ▶ The coloniser just asserted the inferiority of normal math

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Teaching formal math justified by asserting that normal math is inferior.
- ▶ The coloniser just asserted the inferiority of normal math
- ▶ the way racists asserted the inferiority of blacks, browns, reds, yellows.

No dialogue

- ▶ Even today, many in UCT simply assert that the “formal math community”

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

No dialogue

- ▶ Even today, many in UCT simply assert that the “formal math community”
- ▶ is solely authorised to decide what math to teach

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

No dialogue

- ▶ Even today, many in UCT simply assert that the “formal math community”
- ▶ is solely authorised to decide what math to teach
- ▶ This community led by the West

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

No dialogue

- ▶ Even today, many in UCT simply assert that the “formal math community”
- ▶ is solely authorised to decide what math to teach
- ▶ This community led by the West
- ▶ which must be convinced to accept normal math, and reject the formal math it did lifelong

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

No dialogue

- ▶ Even today, many in UCT simply assert that the “formal math community”
- ▶ is solely authorised to decide what math to teach
- ▶ This community led by the West
- ▶ which must be convinced to accept normal math, and reject the formal math it did lifelong
- ▶ **without a public dialogue.**

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Decolonisation means decisions on what math to teach must be made **locally**

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Decolonisation means decisions on what math to teach must be made **locally**
- ▶ they must be made **transparently**: math teachers ought to be responsible to their immediate society

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Decolonisation means decisions on what math to teach must be made **locally**
- ▶ they must be made **transparently**: math teachers ought to be responsible to their immediate society
- ▶ and must **publicly** explain why they teach what they teach.

Trust the West?

- ▶ Leaders of the “formal math community” may be **dishonest**,

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Trust the West?

- ▶ Leaders of the “formal math community” may be **dishonest**,
- ▶ like Sir Michael Atiyah **the** top mathematician

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Trust the West?

- ▶ Leaders of the “formal math community” may be **dishonest**,
- ▶ like Sir Michael Atiyah **the** top mathematician
- ▶ (only one to get both Fields medal and Abel prize)

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Trust the West?

- ▶ Leaders of the “formal math community” may be **dishonest**,
- ▶ like Sir Michael Atiyah **the** top mathematician
- ▶ (only one to get both Fields medal and Abel prize)
- ▶ who **twice** tried to grab credit for my theory in my **published book**

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Trust the West?

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- ▶ like Sir Michael Atiyah **the** top mathematician
- ▶ (only one to get both Fields medal and Abel prize)
- ▶ who **twice** tried to grab credit for my theory in my **published book**
- ▶ once **after** he was directly informed.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Systemic dishonesty

- ▶ The American Mathematical Society ruled that no apology or correction is needed

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Systemic dishonesty

- ▶ The American Mathematical Society ruled that no apology or correction is needed
- ▶ a belated acknowledgment is OK.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Systemic dishonesty

- ▶ The American Mathematical Society ruled that no apology or correction is needed
- ▶ a belated acknowledgment is OK.
- ▶ It refused to publish that Atiyah was personally informed

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Systemic dishonesty

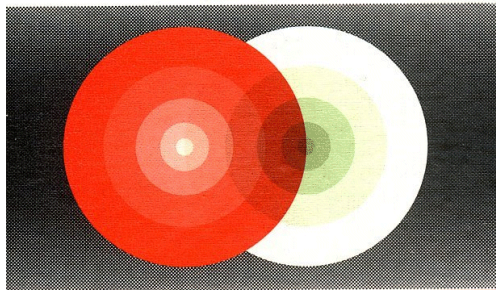
- ▶ The American Mathematical Society ruled that no apology or correction is needed
- ▶ a belated acknowledgment is OK.
- ▶ It refused to publish that Atiyah was personally informed
- ▶ and then did it a **second** time.

Time: Towards a Consistent Theory

by

C. K. Raju

Kluwer Academic Publishers



Fundamental Theories of Physics

Letters to the Editor

Retarded Differential Equations and Quantum Mechanics

G. W. Johnson and I wish to draw attention to the work of C. K. Raju that is related to some of the ideas discussed by Sir Michael Atiyah in his talk “The Nature of Space”, which we reported on in the June/July 2006 issue of the *Notices*. Ideas suggesting a link between retarded differential equations and quantum mechanics were put forward some years ago by Raju, and we, along with Atiyah, believe they deserve attention. Interested readers are encouraged to read, in particular, the following papers written by Raju:

1. *Time: Towards a Consistent Theory*, Kluwer Academic, Dordrecht, 1994 (Fundamental Theories of Physics, vol. 65), ch. 5b “Electromagnetic time” (pp. 116–122), and ch. 6b “Quantum mechanical time” (pp. 161–189).
2. *The Eleven Pictures of Time*, Sage, 2003, pp. 298–302.
3. “The electrodynamic 2-body problem and the origin of quantum mechanics”, *Foundations of Physics*, **34**, (June 2004), 937–962.

—Mark E. Walker
University of Nebraska
mwalker5@math.unl.edu

(Received December 29, 2006)

- ▶ Decolonization aims to overthrow unreasonable Western authority

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Decolonization aims to overthrow unreasonable Western authority
- ▶ especially over the local syllabus.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Decolonization aims to overthrow unreasonable Western authority
- ▶ especially over the local syllabus.
- ▶ (Academics still remain colonised).

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Decolonization aims to overthrow unreasonable Western authority
- ▶ especially over the local syllabus.
- ▶ (Academics still remain colonised).
- ▶ Because Western academics teaches us to trust Western certificates of approval

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ Decolonization aims to overthrow unreasonable Western authority
- ▶ especially over the local syllabus.
- ▶ (Academics still remain colonised).
- ▶ Because Western academics teaches us to trust Western certificates of approval
- ▶ and academics are ranked on the strength of publication in journals controlled by the West.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ Decolonization aims to overthrow unreasonable Western authority
- ▶ especially over the local syllabus.
- ▶ (Academics still remain colonised).
- ▶ Because Western academics teaches us to trust Western certificates of approval
- ▶ and academics are ranked on the strength of publication in journals controlled by the West.
- ▶ Hence constantly driven by a desire for Western approval.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

Simple decolonisation prescription for math

Decolonising
Math and
Science
Education

C. K. Raju

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

▶ #FormalMathMustFall

Introduction

**Normal math vs
formal math**

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Normal math vs formal math

Difference 1

- ▶ So, what is the difference between normal math and formal math?

Difference 1

- ▶ So, what is the difference between normal math and formal math?
- ▶ **Normal math accepts the empirical, formal math prohibits it.**

Difference 1

- ▶ So, what is the difference between normal math and formal math?
- ▶ Normal math accepts the empirical, formal math prohibits it.
- ▶ So, in normal math $1+1=2$ because 1 chair and 1 chair make 2 chairs (that is what most of you learnt as kids).

Difference 1

- ▶ So, what is the difference between normal math and formal math?
- ▶ Normal math accepts the empirical, formal math prohibits it.
- ▶ So, in normal math $1+1=2$ because 1 chair and 1 chair make 2 chairs (that is what most of you learnt as kids).
- ▶ In formal math, Russell needed 378 pages to prove $1+1=2$.

•56'101. $\vdash: R \in \check{\Delta} \equiv . D'R, (\check{C}'R \in 1)$

Dem.

$\vdash . \bullet 55'16 . \bullet 11'11'341 . \supset$

$\vdash: (\exists x, y) . R = x \downarrow y \equiv: (\exists x, y) . D'R = t'x . (\check{C}'R = t'y;$

[•11'54] $\equiv: (\exists x) . D'R = t'x : (\exists y) . (\check{C}'R = t'y;$

[•52'1] $\equiv: D'R, (\check{C}'R \in 1)$

(1)

$\vdash . (1) . \bullet 56'1 . \supset \vdash . \text{Prop}$

•56'102. $\vdash: \check{\Delta} = \check{D}'\check{C}'1 \cap \check{C}'\check{C}'1$

Dem.

$\vdash . \bullet 56'101 . \bullet 37'106 . \supset$

$\vdash: R \in \check{\Delta} \equiv . R \in \check{D}'\check{C}'1 . R \in \check{C}'\check{C}'1 .$

[•22'33] $\equiv . R \in \check{D}'\check{C}'1 \cap \check{C}'\check{C}'1 : \supset \vdash . \text{Prop}$

•56'103. $\vdash: R \in \check{\Delta} . \supset . \check{\eta} ! R$

Dem.

$\vdash . \bullet 56'101 . \supset \vdash: R \in \check{\Delta} . \supset . D'R \in 1 .$

[•52'16] $\supset . \check{\eta} ! D'R .$

[•33'24] $\supset . \check{\eta} ! R : \supset \vdash . \text{Prop}$

•56'104. $\vdash: R \in 0 . \equiv . R = \check{\Lambda}$ [(•56'03)]

•56'11. $\vdash: R \in 2 . \equiv . (\exists x, y) . x \neq y . R = x \downarrow y$ [(•20'3 . (•56'02)]

•56'111. $\vdash: R \in 2 . \equiv . D'R, (\check{C}'R \in 1) . D'R \cap (\check{C}'R = \check{\Lambda})$

Dem.

$\vdash . \bullet 51'231 . \bullet 55'16 . \supset$

$\vdash: x \neq y . R = x \downarrow y \equiv . t'x \cap t'y = \check{\Lambda} . D'R = t'x . (\check{C}'R = t'y .$

[•13'193] $\equiv . D'R \cap (\check{C}'R = \check{\Lambda}) . D'R = t'x . (\check{C}'R = t'y$ (1)

$\vdash . (1) . \bullet 56'11 . \bullet 11'11'341 . \supset$

$\vdash: R \in 2 . \equiv: (\exists x, y) . D'R \cap (\check{C}'R = \check{\Lambda}) . D'R = t'x . (\check{C}'R = t'y;$

[•11'45] $\equiv: D'R \cap (\check{C}'R = \check{\Lambda}) : (\exists x, y) . D'R = t'x . (\check{C}'R = t'y;$

[•11'54] $\equiv: D'R \cap (\check{C}'R = \check{\Lambda}) : (\exists x) . D'R = t'x : (\exists y) . (\check{C}'R = t'y;$

[•52'1] $\equiv: D'R \cap (\check{C}'R = \check{\Lambda}) . D'R, (\check{C}'R \in 1) : \supset \vdash . \text{Prop}$

•56'112. $\vdash: R \in 2 . \equiv . D'R, (\check{C}'R \in 1) . \check{C}'R \in 2$

Dem.

$\vdash . \bullet 56'111 . \bullet 54'43 . \supset$

$\vdash: R \in 2 . \equiv . D'R, (\check{C}'R \in 1) . D'R \cup (\check{C}'R \in 2 .$

[•33'16] $\equiv . D'R, (\check{C}'R \in 1) . \check{C}'R \in 2 : \supset \vdash . \text{Prop}$

•56'113. $\vdash: 2_r = \check{2} \cap \check{C}'\check{C}'2$

Dem.

$\vdash . \bullet 56'112'101 . \supset \vdash: R \in 2_r \equiv . R \in \check{2} . \check{C}'R \in 2 .$

[•37'106 . •33'122] $\equiv . R \in \check{2} . R \in \check{C}'\check{C}'2 .$

[•22'33] $\equiv . R \in \check{2} \cap \check{C}'\check{C}'2 : \supset \vdash . \text{Prop}$

- ▶ Since science and engineering are about the real world, they accept empirical proofs.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Since science and engineering are about the real world, they accept empirical proofs.
- ▶ So, the use of normal math (with empirical proofs) involves no loss

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Since science and engineering are about the real world, they accept empirical proofs.
- ▶ So, the use of normal math (with empirical proofs) involves no loss
- ▶ (but a gain: normal math is easy so students are able to solve much harder problems).

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

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Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

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- ▶ (but a gain: normal math is easy so students are able to solve much harder problems).
- ▶ For example, non-elementary elliptic integrals are not taught as part of usual university calculus courses
- ▶ but taught in decolonised calculus.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ So, **if** the purpose of teaching math is

- ▶ So, **if** the purpose of teaching math is
- ▶ for its practical applications to science and engineering

- ▶ So, **if** the purpose of teaching math is
- ▶ for its practical applications to science and engineering
- ▶ we should teach normal math. **But**

- ▶ Formal math begins from axioms

Introduction

**Normal math vs
formal math**

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Formal math begins from axioms
- ▶ **invariably laid down by Western authority.**

Introduction

**Normal math vs
formal math**

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Formal math begins from axioms
- ▶ **invariably laid down by Western authority.**
- ▶ So, fall of formal math means loss of authority for the West.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Formal math begins from axioms
- ▶ **invariably laid down by Western authority.**
- ▶ So, fall of formal math means loss of authority for the West.
- ▶ Terrible!?

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Formal math begins from axioms
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- ▶ So, fall of formal math means loss of authority for the West.
- ▶ Terrible!?
- ▶ But that is exactly what decolonisation is about

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Formal math begins from axioms
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- ▶ Terrible!?
- ▶ But that is exactly what decolonisation is about
- ▶ overthrow of colonial authority

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Formal math begins from axioms
- ▶ **invariably laid down by Western authority.**
- ▶ So, fall of formal math means loss of authority for the West.
- ▶ Terrible!?
- ▶ But that is exactly what decolonisation is about
- ▶ overthrow of colonial authority
- ▶ on the last colonial frontier: academics.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Difference 2

- ▶ Normal math is EASY

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- ▶ a child understands $1+1=2$ empirically.

Difference 2

- ▶ Normal math is EASY
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- ▶ But does anyone here understands the 378 page proof of $1+1=2$ in the *Principia*?

Difference 2

- ▶ Normal math is EASY
- ▶ a child understands $1+1=2$ empirically.
- ▶ But does anyone here understands the 378 page proof of $1+1=2$ in the *Principia*?
- ▶ Today $1+1=2$ proved using set theory, but even most math experts never learn formal set theory, for it is too hard.

Difference 2

- ▶ Normal math is EASY
- ▶ a child understands $1+1=2$ empirically.
- ▶ But does anyone here understands the 378 page proof of $1+1=2$ in the *Principia*?
- ▶ Today $1+1=2$ proved using set theory, but even most math experts never learn formal set theory, for it is too hard.
- ▶ (They just trust the math community, despite paradoxes, such as Banach-Tarski paradox.)

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ So, formal math makes the simplest things like $1+1=2$ too hard for most people.

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- ▶ They have no option but to trust the West,

- ▶ So, formal math makes the simplest things like $1+1=2$ too hard for most people.
- ▶ They have no option but to trust the West,
- ▶ and become perpetually dependent on the West.

Another example

Geometric points

- ▶ Since $1+1=2$ is too hard, let us take an easier example.

Another example

Geometric points

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- ▶ School texts (class 6) in India teach

Another example

Geometric points

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Geometric points

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- ▶ “geometric points are invisible”.
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Another example

Geometric points

- ▶ Since $1+1=2$ is too hard, let us take an easier example.
- ▶ School texts (class 6) in India teach
- ▶ “geometric points are invisible”.
- ▶ But this is a **con-trick**.
- ▶ Like the emperor’s invisible new clothes

Another example

Geometric points

- ▶ Since $1+1=2$ is too hard, let us take an easier example.
- ▶ School texts (class 6) in India teach
- ▶ “geometric points are invisible”.
- ▶ But this is a **con-trick**.
- ▶ Like the emperor’s invisible new clothes
- ▶ which are visible only to the intelligent.

King's invisible new clothes



Decolonising
Math and
Science
Education

C. K. Raju

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Invisible points don't exist on **common sense**.

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- ▶ Through formal math, students are taught to reject commonsense

- ▶ Invisible points don't exist on **common sense**.
- ▶ Through formal math, students are taught to reject commonsense
- ▶ and **trust the authority of the school text**

- ▶ Invisible points don't exist on **common sense**.
- ▶ Through formal math, students are taught to reject commonsense
- ▶ and **trust the authority of the school text**
- ▶ which derives from the West.

Introduction

Normal math vs
formal math

**Colonial
education and
colonialism**

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Colonial education and colonialism

- ▶ This is as per plan.

Introduction

Normal math vs
formal math

**Colonial
education and
colonialism**

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ This is as per plan.
- ▶ Colonial higher education came as church education.

Introduction

Normal math vs
formal math

**Colonial
education and
colonialism**

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ This is as per plan.
- ▶ Colonial higher education came as church education.
- ▶ All early universities like Cambridge, Oxford, Paris, Bologna,

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ This is as per plan.
- ▶ Colonial higher education came as church education.
- ▶ All early universities like Cambridge, Oxford, Paris, Bologna,
- ▶ were set up by the church during the Crusades to mass produce indoctrinated missionaries.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ This is as per plan.
- ▶ Colonial higher education came as church education.
- ▶ All early universities like Cambridge, Oxford, Paris, Bologna,
- ▶ were set up by the church during the Crusades to mass produce indoctrinated missionaries.
- ▶ Were 100% controlled by the church until the 20th c.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ So, colonial/church education was designed to indoctrinate its products

- ▶ So, colonial/church education was designed to indoctrinate its products
- ▶ to fanatically trust authority against commonsense

- ▶ So, colonial/church education was designed to indoctrinate its products
- ▶ to fanatically trust authority against commonsense
- ▶ e.g. virgin birth, the basis of church ethics.

- ▶ Macaulay told the colonised (in India, 1835) they needed Western education for science

- ▶ Macaulay told the colonised (in India, 1835) they needed Western education for science
- ▶ but told the British parliament (in 1847) that education was the cheapest way to contain revolts.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ Macaulay told the colonised (in India, 1835) they needed Western education for science
- ▶ but told the British parliament (in 1847) that education was the cheapest way to contain revolts.
- ▶ First universities set up in India immediately after the revolt of 1857.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Strange that the church (supposedly against science)

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- ▶ brought science to the heathen. Why?

- ▶ Strange that the church (supposedly against science)
- ▶ brought science to the heathen. Why?
- ▶ To commit harakiri by introducing one enemy to another?

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Strange that the church (supposedly against science)
- ▶ brought science to the heathen. Why?
- ▶ To commit harakiri by introducing one enemy to another?
- ▶ Best science colleges in India are still church institutions.

- ▶ It is a myth that colonialism was established by guns.

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- ▶ In India, **the coloniser was militarily weak,**

- ▶ It is a myth that colonialism was established by guns.
- ▶ In India, **the coloniser was militarily weak**,
- ▶ and could not match the military might of the Moghul empire (or even the Vijaynagar empire)

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ It is a myth that colonialism was established by guns.
- ▶ In India, **the coloniser was militarily weak**,
- ▶ and could not match the military might of the Moghul empire (or even the Vijaynagar empire)
- ▶ Western gun and steel technology was **very inferior then**

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ The first military victory (skirmish of Plassey) was won after 250 years in 1757

- ▶ The first military victory (skirmish of Plassey) was won **after 250 years** in 1757
- ▶ using an advanced technique

- ▶ The first military victory (skirmish of Plassey) was won **after 250 years** in 1757
- ▶ using an advanced technique
- ▶ of **bribery and deceit**.

- ▶ Then West was **still scientifically challenged**: did not know how to navigate.

- ▶ Then West was **still scientifically challenged**: did not know how to navigate.
- ▶ The British Longitude prize was given away only in 1762

- ▶ Then West was **still scientifically challenged**: did not know how to navigate.
- ▶ The British Longitude prize was given away only in 1762
- ▶ (and only half the prize was given, for they were not sure whether it had been won!).

Decolonise education

Decolonising
Math and
Science
Education

C. K. Raju

Introduction

Normal math vs
formal math

**Colonial
education and
colonialism**

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ For a free people we need to redesign education fundamentally

Decolonise education

- ▶ For a free people we need to redesign education fundamentally
- ▶ to free the mind, not enslave it.

Introduction

Normal math vs
formal math

**Colonial
education and
colonialism**

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Myths and superstitions of formal math

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ To return to formal math

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ To return to formal math
- ▶ because it originates with the church/West

- ▶ To return to formal math
- ▶ because it originates with the church/West
- ▶ formal math is accompanied by myths and superstitions.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Two key myths are about (a) “Euclid” and (b) his deductive proofs.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Two key myths are about (a) “Euclid” and (b) his deductive proofs.
- ▶ Both are **complete falsehoods** taught through our math texts.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Two key myths are about (a) “Euclid” and (b) his deductive proofs.
- ▶ Both are **complete falsehoods** taught through our math texts.
- ▶ There is nil evidence for the existence of “Euclid” (or his white skin)

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Two key myths are about (a) “Euclid” and (b) his deductive proofs.
- ▶ Both are **complete falsehoods** taught through our math texts.
- ▶ There is nil evidence for the existence of “Euclid” (or his white skin)
- ▶ There is not a single pure deductive proof in the book *Elements* he supposedly wrote.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Two key myths are about (a) “Euclid” and (b) his deductive proofs.
- ▶ Both are **complete falsehoods** taught through our math texts.
- ▶ There is nil evidence for the existence of “Euclid” (or his white skin)
- ▶ There is not a single pure deductive proof in the book *Elements* he supposedly wrote.
- ▶ The book was written by **another person** at **another time** for **another (religious) purpose**.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

Euclid and Jesus



C. K. Raju



Multiversity



Citizens International

- ▶ Some people got furious: at the point that “Euclid” was a black woman.

- ▶ Some people got furious: at the point that “Euclid” was a black woman.
- ▶ But no one dared claim my prize of ZAR 40K for the slightest serious evidence about “Euclid”.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Some people got furious: at the point that “Euclid” was a black woman.
- ▶ But no one dared claim my prize of ZAR 40K for the slightest serious evidence about “Euclid”.
- ▶ in the **last seven years**

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Some people got furious: at the point that “Euclid” was a black woman.
- ▶ But no one dared claim my prize of ZAR 40K for the slightest serious evidence about “Euclid”.
- ▶ in the **last seven years**
- ▶ because that would involve a public discussion.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

▶ #EuclidMustFall

- ▶ The myths of formal math are accompanied by **superstitions**.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ The myths of formal math are accompanied by **superstitions**.
- ▶ Western claim: deductive proof is infallible.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ The myths of formal math are accompanied by **superstitions**.
- ▶ Western claim: deductive proof is infallible.
- ▶ Deductive proofs are obviously fallible:

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ The myths of formal math are accompanied by **superstitions**.
- ▶ Western claim: deductive proof is infallible.
- ▶ Deductive proofs are obviously fallible:
- ▶ an invalid deductive proof may be mistaken for a valid one:

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ The myths of formal math are accompanied by **superstitions**.
- ▶ Western claim: deductive proof is infallible.
- ▶ Deductive proofs are obviously fallible:
- ▶ an invalid deductive proof may be mistaken for a valid one:
- ▶ all Western scholars mistook the proofs in the *Elements* as valid deductive proofs for over **7 centuries**.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ During the Crusades the church adopted the theology of reason

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ During the Crusades the church adopted the theology of reason
- ▶ and used the *Elements* to teach reasoning to its priests (we still follow that Cambridge syllabus).

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ During the Crusades the church adopted the theology of reason
- ▶ and used the *Elements* to teach reasoning to its priests (we still follow that Cambridge syllabus).
- ▶ However, **the church notion of reasoning involved a trick**

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ During the Crusades the church adopted the theology of reason
- ▶ and used the *Elements* to teach reasoning to its priests (we still follow that Cambridge syllabus).
- ▶ However, **the church notion of reasoning involved a trick**
- ▶ it started from (anti-empirical) metaphysical premises,

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ During the Crusades the church adopted the theology of reason
- ▶ and used the *Elements* to teach reasoning to its priests (we still follow that Cambridge syllabus).
- ▶ However, **the church notion of reasoning involved a trick**
- ▶ it started from (anti-empirical) metaphysical premises,
- ▶ **so it could be used to prove any pre-determined conclusion whatsoever**, which suited authority.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ The Lokayata in India rejected inference when done without empirically verifying the premises.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ The Lokayata in India rejected inference when done without empirically verifying the premises.
- ▶ E.g. wolf's footprints.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ The premises of formal math can never be empirically verified,

- ▶ The premises of formal math can never be empirically verified,
- ▶ because even at the level of geometric points and $1+1=2$

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ The premises of formal math can never be empirically verified,
- ▶ because even at the level of geometric points and $1+1=2$
- ▶ they involve an anti-empirical metaphysics (fantasy) of infinity.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

Finer point

- ▶ That metaphysics (fantasy) of infinity

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Finer point

- ▶ That **metaphysics (fantasy) of infinity**
- ▶ is closely tied to **church dogmas of eternity.**

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Finer point

- ▶ That **metaphysics (fantasy) of infinity**
- ▶ is closely tied to **church dogmas of eternity**.
- ▶ See, “Curse on ‘cyclic’ time” in *Eleven Pictures of Time*, Sage, 2003, and my article on “Eternity and infinity” (Google).

The Eleven Pictures of Time

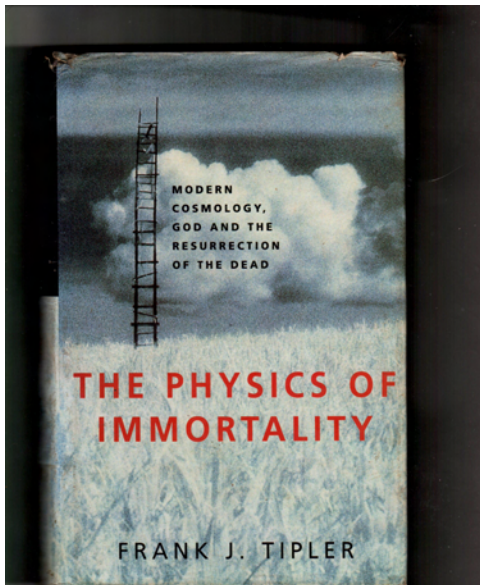
*The Physics, Philosophy, and
Politics of Time Beliefs*



C. K. Raju

An example of nonsense

certified by the journal *Nature*



Decolonising
Math and
Science
Education

C. K. Raju

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Through the bad metaphysics of formal math

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Through the bad metaphysics of formal math
- ▶ (and, in particular, calculus)

- ▶ Through the bad metaphysics of formal math
- ▶ (and, in particular, calculus)
- ▶ church dogmas creep into science.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

THE
PHYSICS
OF
IMMORTALITY

Modern Cosmology,

God and the

Resurrection of the Dead

Decolonising
Math and
Science
Education

C. K. Raju

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

IX. THE PHYSICS OF RESURRECTION OF THE DEAD TO
ETERNAL LIFE 217

Social Immortality as a Consequence of the Omega Point Theory 217

The Physical Mechanism of Individual Resurrection 219

*Proof That an Emulation of the Entire Visible Universe Is Physically
Possible* 221

When Will the Dead Be Raised? 225

Why Will the Dead Be Raised? 227

The Pattern (Form) Theory Versus the Continuity Theory of Identity 227

Quantum Mechanics Supports the Pattern Identity Theory 230

Tipler quote

- ▶ “theology is a branch of physics, . . . physicists can infer by calculation the existence of God

Tipler quote

- ▶ “theology is a branch of physics, . . . physicists can infer by calculation the existence of God
- ▶ and the likelihood of the resurrection of the dead to eternal life in exactly the same way as physicists calculate the properties of the electron.

Tipler quote

- ▶ “theology is a branch of physics, . . . physicists can infer by calculation the existence of God
- ▶ and the likelihood of the resurrection of the dead to eternal life in exactly the same way as physicists calculate the properties of the electron.
- ▶ the central claims of Judeo-Christian theology are in fact true,

Tipler quote

- ▶ “theology is a branch of physics, . . . physicists can infer by calculation the existence of God
- ▶ and the likelihood of the resurrection of the dead to eternal life in exactly the same way as physicists calculate the properties of the electron.
- ▶ the central claims of Judeo-Christian theology are in fact true,
- ▶ . . . these claims are straightforward deductions of the laws of physics as we now understand them.

- ▶ I have been forced into these conclusions by the inexorable logic of my own special branch of physics. . . the area of global general relativity. . . created. . . by the great British physicists Roger Penrose and **Stephen Hawking**.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Tipler only explains

- ▶ Tipler only explains
- ▶ the irrefutable theology in Stephen Hawking's singularity theory.

- ▶ Tipler only explains
- ▶ the irrefutable theology in Stephen Hawking's singularity theory.
- ▶ See my newspaper article for a popular-level account.



PTV Sunday

THE mag

Monday, January 16, 2011

The Christian propaganda in Hawking's work

What do the Pope and Stephen Hawking have in common? Both propagate a Christian view of how the universe came into being. While the Pope is direct, seeing the hand of God in the Big Bang, Hawking does it more subtly. His popular books provide a scientific veneer to Christian theology, while projecting non-Christian views of creation as unscientific, reveals Professor CK Raju, who is currently with the School of Mathematical Sciences, Universiti Sains Malaysia



Stephen Hawking's The Universe in a Nutshell. Photo: Amazon.com

Stephen Hawking's new book, The Universe in a Nutshell, has caused a stir in the Christian community. In it, he argues that the universe was created by God, but that God is not a deity in the traditional sense. He is a "deity" who is not a person, but a force. This is a subtle way of saying that the universe was created by God, but that God is not a deity in the traditional sense. He is a "deity" who is not a person, but a force.

The introduction of religion into science was not done by the church, but by the scientists themselves. They wanted to explain the universe in terms of God, but they were not willing to do so in a way that would be accepted by the scientific community. This is why the church has always been a part of the scientific process, and why it has always been a part of the scientific process.

Christianity and the Bible. The Bible is a collection of books that were written by people who were living in a time when the world was very different from the world we live in today. It is a collection of books that were written by people who were living in a time when the world was very different from the world we live in today. It is a collection of books that were written by people who were living in a time when the world was very different from the world we live in today.



Photo: Wikimedia Commons

Pollock's work, and really. The work of the artist is to create a world that is different from the world we live in. It is to create a world that is different from the world we live in. It is to create a world that is different from the world we live in.



CONFESSION

In a nutshell

Politics of creation

Politics of creation. The politics of creation is a complex issue that involves many different groups of people. It is a complex issue that involves many different groups of people. It is a complex issue that involves many different groups of people.

Half-hearted science

Half-hearted science. Science is a process of discovery that is based on evidence and reason. It is a process of discovery that is based on evidence and reason. It is a process of discovery that is based on evidence and reason.

God's hand in Big Bang

God's hand in Big Bang. The Big Bang is a theory that explains the origin of the universe. It is a theory that explains the origin of the universe. It is a theory that explains the origin of the universe.

Science is a process of discovery that is based on evidence and reason. It is a process of discovery that is based on evidence and reason. It is a process of discovery that is based on evidence and reason.

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Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Is anyone here willing to laugh at the

- ▶ Is anyone here willing to laugh at the
- ▶ combined authority of Nature, and Stephen Hawking?

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Is anyone here willing to laugh at the
- ▶ combined authority of Nature, and Stephen Hawking?
- ▶ Laugh!

- ▶ Is anyone here willing to laugh at the
- ▶ combined authority of Nature, and Stephen Hawking?
- ▶ Laugh!
- ▶ For what they assert is as wrong as the case of the UCT student who is endlessly attacked.

A last point

Logic

- ▶ Lastly, formal math uses 2-valued (“Aristotelian”) logic for proofs,

A last point

Logic

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- ▶ on the naive theological assumption that logic is universal (“logic binds god”)

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Logic

- ▶ Lastly, formal math uses 2-valued (“Aristotelian”) logic for proofs,
- ▶ on the naive theological assumption that logic is universal (“logic binds god”)
- ▶ But, from before even the real Aristotle, Buddhists and Jains used a different logic

A last point

Logic

- ▶ Lastly, formal math uses 2-valued (“Aristotelian”) logic for proofs,
- ▶ on the naive theological assumption that logic is universal (“logic binds god”)
- ▶ But, from before even the real Aristotle, Buddhists and Jains used a different logic
- ▶ similar to quantum logic which empirically prevails in the micro-domain.

- ▶ Thus, a valid formal mathematical theorem

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Thus, a valid formal mathematical theorem
- ▶ is **not** a necessary consequence of the postulates

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Thus, a valid formal mathematical theorem
- ▶ is **not** a necessary consequence of the postulates
- ▶ theorems vary with both postulates and logic

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Thus, a valid formal mathematical theorem
- ▶ is **not** a necessary consequence of the postulates
- ▶ theorems vary with both postulates and logic
- ▶ (E.g. in calculus, existence of a Lebesgue non-measurable set cannot be proved with quasi truth-functional logic.)

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

Interim summary

- ▶ No “Euclid”.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Interim summary

- ▶ No “Euclid”.
- ▶ No pure deductive proofs in the *Elements*.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Deductive proofs fallible (an invalid proof may be mistaken for a valid one).

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Deductive proofs fallible (an invalid proof may be mistaken for a valid one).
- ▶ Anti-empirical deductive proofs can be used to prove anything. (Any pre-determined conclusion may be proved deductively starting from suitable premises.)

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Deductive proofs fallible (an invalid proof may be mistaken for a valid one).
- ▶ Anti-empirical deductive proofs can be used to prove anything. (Any pre-determined conclusion may be proved deductively starting from suitable premises.)
- ▶ All postulates underlying formal math (of even $1+1=2$) are metaphysical and cannot be empirically verified.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ Deductive proofs fallible (an invalid proof may be mistaken for a valid one).
- ▶ Anti-empirical deductive proofs can be used to prove anything. (Any pre-determined conclusion may be proved deductively starting from suitable premises.)
- ▶ All postulates underlying formal math (of even $1+1=2$) are metaphysical and cannot be empirically verified.
- ▶ 2-valued logic is neither culturally universal nor empirically certain. Hence

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

▶ #FormalMathMustFall

A common doubt

- ▶ Doesn't formal math work in practice?

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

A common doubt

- ▶ Doesn't formal math work in practice?
- ▶ **NO.**

Resolution of the doubt

- ▶ What works is normal math, **not** formal math, for all practical applications.

Resolution of the doubt

- ▶ What works is normal math, **not** formal math, for all practical applications.
- ▶ For example, calculus is taught using formal real numbers.

Resolution of the doubt

- ▶ What works is normal math, **not** formal math, for all practical applications.
- ▶ For example, calculus is taught using formal real numbers.
- ▶ But not even a single formal real number such as $\sqrt{2}$ can ever be written down EXACTLY.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

Resolution of the doubt

- ▶ What works is normal math, **not** formal math, for all practical applications.
- ▶ For example, calculus is taught using formal real numbers.
- ▶ But not even a single formal real number such as $\sqrt{2}$ can ever be written down EXACTLY.
- ▶ Formal real numbers are not real,

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

Resolution of the doubt

- ▶ What works is normal math, **not** formal math, for all practical applications.
- ▶ For example, calculus is taught using formal real numbers.
- ▶ But not even a single formal real number such as $\sqrt{2}$ can ever be written down EXACTLY.
- ▶ Formal real numbers are not real,
- ▶ hence can **never** be used for practical applications.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ A computer (real computer, NOT Turing machine)

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ A computer (real computer, NOT Turing machine)
- ▶ can hence never use formal real numbers.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ A computer (real computer, NOT Turing machine)
- ▶ can hence never use formal real numbers.
- ▶ It uses real **floating point numbers**.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

**Myths and
superstitions of
formal math**

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ A computer (real computer, NOT Turing machine)
- ▶ can hence never use formal real numbers.
- ▶ It uses real **floating point numbers**.
- ▶ Anything that can be done using computers is normal math.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ A computer (real computer, NOT Turing machine)
- ▶ can hence never use formal real numbers.
- ▶ It uses real **floating point numbers**.
- ▶ Anything that can be done using computers is normal math.
- ▶ (Most practical applications are done using computers today.)

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

The alternative

- ▶ The alternative math worked out by the Multiversity group (Malaysia, Iran, India)

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ The alternative math worked out by the Multiversity group (Malaysia, Iran, India)
- ▶ over the last decade

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ The alternative math worked out by the Multiversity group (Malaysia, Iran, India)
- ▶ over the last decade
- ▶ Tested with experiments with 8 groups in 5 universities, across 3 countries.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ The alternative math worked out by the Multiversity group (Malaysia, Iran, India)
- ▶ over the last decade
- ▶ Tested with experiments with 8 groups in 5 universities, across 3 countries.
- ▶ Being taught to (school and) university students today in India.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ Easiest way to understand the alternative is through history:

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ Easiest way to understand the alternative is through history:
- ▶ Euclid etc. not the sole falsehoods of Western history

- ▶ Easiest way to understand the alternative is through history:
- ▶ Euclid etc. not the sole falsehoods of Western history
- ▶ that includes Copernicus, Newton (calculus), and many others.

- ▶ Note: not proposing rejection of everything Western

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Note: not proposing rejection of everything Western
- ▶ but only a critical rejection

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Note: not proposing rejection of everything Western
- ▶ but only a critical rejection
- ▶ as publicly explained in debates in Malaysia long ago.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion



LETTER

mailto:thesunday@on.com

Be critical and choose what is best

This refers to "East, west, what's best?" (Comment by E. John, Aug 11), which treated a whole group of children as emotional and communal, by giving a totally distorted account of the difficulties at the deconstruction conference. The comment at the deconstruction conference is that, unlike the 'critical' agencies of the movement by the west, though some really meanly appreciate, our rejection of the west must be a critical one, and choose what is best.

For example, our legal system copies the west. As Stud Feung further pointed out, judges are required to be trained in British law, and need not know even the Malayan constitution. The demand to correct such anomalies is neither reasonable nor even valid, this is a clear case where applying the west hurts our interests. As the US history strategist Huntington bluntly said, applying the west hurts the colonised former ruler western rule.

At the conference, I suggested concrete reforms to the western maths and science curriculum, because that results in practical advantages for us. In fact, I suggested we should teach calculus without limits. This makes maths easy, so more maths students can do advanced maths, while maths students can solve harder problems.

This has many practical benefits. For example, if a manager personally understood the complex mathematics of risk, that would help them avoid wrong deci-

sions, like those which led to the sub-prime crisis. I also proposed we teach better science using functional/differential equations, and pointing to its practical advantages over Newton's "laws" for quantum computing, knowledge, space flight, and galactic structure. We should adjust both these proposals evenly because they work better.

But even more the mathematics. How do we implement the new curriculum at our schools and universities? Because solutions have assessed that most people remain mathematically and scientifically illiterate. So, we are forced to only use easy parts.

"Our papers" are all trained in the western tradition, and our method of teaching operates to the west without modification, so our papers are wholly dependent on the west. It is a major conflict of interest for those to admit the western method is inferior. We have no procedure, such as public debate, to assess transparency, and "papers" typically make decisions behind-the-scenes. The result will make it difficult for us to do what is good for us.

Now, if every innovation needs western approval, that systematically gives the west the first choice to grab that innovation and its benefits. The way a former president of the Royal Society twice tried to grab credit for slow recognition to use functional/differential equations, the second now, after he had been explicitly informed about it (Please see the latest acknowledgment of my work at <http://www.ams.org/chronicles/2008/08/merriman-math.pdf>, second page, and the finding of a prior factor name against him at <http://www.sciencemag.com/cgi/content/full/306/5702/1207>, 1208th-1209th lines).

However, there is an even deeper problem. The western bias in Florida's "law" (mentioned in my earlier letter/comment) just because Christian theology got mixed with mathematics in the west. People astonished by this claim are usually unaware that the very word mathematics derived from "mathema", a term imbued with deep religious meaning and related to the soul and its part here by Aristotle in his famous dialogue with the slave boy in Plato's *Menon*.

Although early Christians had similar beliefs about the soul, the post-Enlightenment rationalist the belief, and banned philosophy such as Proclus, calling them heretics (which allowed killing them) because they used the use of mathematics to reject the Christian doctrine of creation.

So, we can see how mathematics got into the dead-center of the vicious religious war waged against "pagans" begun in the fourth century. The next religious war, the Crusades against the Muslims, failed in Earth beyond Spain, and the check booked for money to convert Muslims who did not accept the Christian religion, and could not be converted by force, until "pagans" Sa'ad Malik was accepted (see http://en.wikipedia.org/wiki/Sa'ad_Malik), and his schoolmen advocated a Christian theology of reason. To convert them,

Mathematics was now accepted back by the church, but discov-

ered from "soul", and used only as a tool to teach reason. I can explain some of this in "The Religion Roots of Mathematics" (Theory, Culture and Society, 2006) available from <http://dx.doi.org/10.1080/14737790600600000>. Religion-roots-of-math-TCS.pdf, and my book Cultural Foundations of Mathematics (Pearson, 2007).

The western claim to ownership of rationality is incorrect, as further explained in my article for the *Journal of Mathematics*, in Indian Journal of Mathematics, 2007, available from <http://www.ijm.ams.in/issue/01-07-2007/101-111.pdf>, and my book *Mathematics for the 21st Century* (see my article in *Journal of Mathematics* for the September issue).

Current western formal mathematics developed out of that post-Creationist best of reason. The view of math-as-proof-for-permission is irrelevant for any practical application of maths, such as teaching a man to the moon, all of which require math-as-creation.

To rejecting formalism will not hurt the practical applications of maths at all. To the contrary, it makes maths easy, and enhances the ability of students to apply it to more complex practical problems.

However, the west is deeply invested into that form that metaphysics which involves anti-Creation and anti-Biblical, anti-Hindu, etc. bias.

(1) This formalism assumes that mathematical proofs are more trustworthy than empirical proofs, contrary to all Indian philosophies.

(2) Similarly, like western philosophy for centuries, mistakenly assumed that logic is universal, though Buddhist and Jain logics are different, like quantum logics. (See my article in "Logic" in the *Springer Encyclopedia of the History of Ideas*, 2008, available from http://dx.doi.org/10.1007/978-1-4020-9056-5_14).

(3) Though formal maths can, in principle, begin from any postulates, students are taught only those postulates of arithmetic laid down by western mathematicians.

Those are incompatible with Islamic beliefs about eternity and computer arithmetic, which latter declined in western. (See details in my paper in *Journal of Science and Culture*, 2011) on "Formal mathematics vs based metaphysics" at http://dx.doi.org/10.1007/978-1-4020-9056-5_14.

The religion bias in present-day maths makes it teach a non-rationalist in a secular society, like India, and in Muslim countries which do not permit a pro-Christian bias. So, its teaching cannot be immediately changed across schools and universities.

The change I suggested is better also from a purely practical perspective. Thus, the correct position is the exact opposite of what John treated: namely, that we want to change the educational system for our pragmatic benefit, and to discuss and/or use western maths and science. Now that the position has been clarified, I hope John will join us in our endeavor.

E. K. Raja
 Visiting Professor
 School of Mathematical Sciences
 Universiti Sains Malaysia



- ▶ To be able to learn from the past,

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ To be able to learn from the past,
- ▶ Western myths must be replaced

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ To be able to learn from the past,
- ▶ Western myths must be replaced
- ▶ by the **real history of math and science.**

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ To be able to learn from the past,
- ▶ Western myths must be replaced
- ▶ by the **real history of math and science**.
- ▶ (Greeks were arithmetically challenged: contributed NOTHING to math.)

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Most math (arithmetic, algebra, geometry, trigonometry, calculus, probability)

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Most math (arithmetic, algebra, geometry, trigonometry, calculus, probability)
- ▶ originated as normal math in the non-West.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Most math (arithmetic, algebra, geometry, trigonometry, calculus, probability)
- ▶ originated as normal math in the non-West.
- ▶ It was imported by the West for its practical value.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Most math (arithmetic, algebra, geometry, trigonometry, calculus, probability)
- ▶ originated as normal math in the non-West.
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- ▶ E.g. arithmetic for commerce,

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

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- ▶ originated as normal math in the non-West.
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Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ Most math (arithmetic, algebra, geometry, trigonometry, calculus, probability)
- ▶ originated as normal math in the non-West.
- ▶ It was imported by the West for its practical value.
- ▶ E.g. arithmetic for commerce,
- ▶ trigonometry and calculus for navigation,
- ▶ probability for games of chance.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ The mathematically challenged West took centuries to understand what it imported.

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- ▶ The very names tell this story.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ The mathematically challenged West took centuries to understand what it imported.
- ▶ The very names tell this story.
- ▶ E.g Zero from zephyr or sifr = cypher = mysterious code.

- ▶ Because primitive Greek/Roman numerals are additive, but zero involves place value

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ Because primitive Greek/Roman numerals are additive, but zero involves place value
- ▶ Hence, Florence passed a law against zero in 13th c.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ Because primitive Greek/Roman numerals are additive, but zero involves place value
- ▶ Hence, Florence passed a law against zero in 13th c.
- ▶ Financial contracts using “Arabic” numerals must also be written also in words (as we still do).

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ The word “sine” derives from Latin sinus = fold

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ The word “sine” derives from Latin sinus = fold
- ▶ from Arabic *jaib* (according to OED)

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ The word “sine” derives from Latin sinus = fold
- ▶ from Arabic *jaib* (according to OED)
- ▶ a misreading of jiba from Sanskrit jiva or jya = chord, **relates to the circle.**

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ The word “sine” derives from Latin sinus = fold
- ▶ from Arabic *jaib* (according to OED)
- ▶ a misreading of jiba from Sanskrit jiva or jya = chord, **relates to the circle.**
- ▶ “Trigonometry” involves a conceptual confusion: it should be “circle-metry”

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ The word “sine” derives from Latin sinus = fold
- ▶ from Arabic *jaib* (according to OED)
- ▶ a misreading of jiba from Sanskrit jiva or jya = chord, **relates to the circle.**
- ▶ “Trigonometry” involves a conceptual confusion: it should be “circle-metry”
- ▶ (But no instrument with which to measure the circle, in present-day geometry box.)

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ (No Claudius Ptolemy, but Egyptians and Iraqis probably knew circlemetry.)

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ (No Claudius Ptolemy, but Egyptians and Iraqis probably knew circlemetry.)
- ▶ Like arithmetic, trigonometry was transmitted in multiple phases.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ (No Claudius Ptolemy, but Egyptians and Iraqis probably knew circlemetry.)
- ▶ Like arithmetic, trigonometry was transmitted in multiple phases.
- ▶ Final phase: directly from India (16th c.) for the specifically European navigational problem:

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ (No Claudius Ptolemy, but Egyptians and Iraqis probably knew circlemetry.)
- ▶ Like arithmetic, trigonometry was transmitted in multiple phases.
- ▶ Final phase: directly from India (16th c.) for the specifically European navigational problem:
- ▶ **precise trigonometric values needed to determine latitude, longitude, and loxodromes.**

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Jesuits stole these values from Cochin

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- ▶ where they were running a college by 1550

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Jesuits stole these values from Cochin
- ▶ where they were running a college by 1550
- ▶ and mass translating local texts to Latin (as they did in Toledo).

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Jesuits stole these values from Cochin
- ▶ where they were running a college by 1550
- ▶ and mass translating local texts to Latin (as they did in Toledo).
- ▶ These precise trigonometric values stated by Madhava (14th c.)

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

Madhava's sine table

श्रेष्ठं नाम वरिष्ठानां हिमाद्रिर्वेदभावनः ।
तपनो भानुसूक्तज्ञो मध्यमं विद्धि दोहनम् ॥
धिगाज्यो नाशनं कष्टं छन्नभोगाशयाम्बिका ।
म्रिगाहारो नरेशोऽयं वीरो रणजयोत्सुकः ॥

...

छायालयो गजो नीलो निर्मलो नास्ति सत्कुले ।
रात्रौ दर्पणमभ्राङ्गं नागस्तुङ्गनखो बली ॥
धीरो युवा कथालोलः पूज्यो नारीजनैर्भगः ।
कन्यागारे नागवल्ली देवो विश्वस्थली भृगुः ॥
तत्परादिकलान्तास्तु महाज्या माधवोदिताः ।
स्वस्वपूर्वविशुद्धे तु शिष्टास्तत्खण्डमौर्विकाः ॥ २.१.५ ॥

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Madhava's sine table

Table: Mādhava's sine values

No.	Kaṭapayādi	kalā (')	vikalā('')	tatparā('''')
1	श्रेष्ठं नाम वरिष्ठानां	224	50	22
2	हिमाद्रिर्वेदभावनः	448	42	58
3	तपनो भानुसूक्तज्ञो	670	40	16
4	मध्यमं विद्धि दोहनम्	889	45	15
...
21	धीरो युवा कथालोलः	3371	41	29
22	पूज्यो नारीजनैर्भगः	3408	20	11
23	कन्यागारे नागवल्ली	3430	23	11
24	देवो विश्वस्थली भृगुः	3437	44	48

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Accuracy of Madhava's sine values

Table: Accuracy of Mādhava's sine table.

No.	Mādhava's sine value	Difference
1	0.0654031452	0.0000000160
2	0.1305262297	0.0000000375
3	0.1950903240	0.0000000020
4	0.2588190035	-0.0000000416
...
...
21	0.9807852980	0.0000000176
22	0.9914448967	0.0000000353
23	0.9978589819	0.0000000587
24	1.0000000000	0.0000000000

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

Āryabhaṭa's table of sine differences

- ▶ Process of calculating accurate sine values began a thousand years earlier
- ▶ with Āryabhaṭa in the 5th c.



मखि भखि फखि धखि राखि जखि
डखि हस्भ्क स्क्कि किष्वा श्घकि किघ्व ।
घ्लकि किग्र हक्य धकि किच
स्वा श्भ्क इव् क्ल प्त फ छ कलार्धज्या ॥ १२ ॥

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ 225, 224, 222, 219, 215, 210, 205, 199, 191, 183, 174, 164, 154, 143, 131, 119, 106, 93, 79, 65, 51, 37, 22, 7—[these are the] Rsine [differences] [for the quadrant divided into as many equal parts, each part hence being 225'] [in] minutes.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ 225, 224, 222, 219, 215, 210, 205, 199, 191, 183, 174, 164, 154, 143, 131, 119, 106, 93, 79, 65, 51, 37, 22, 7—[these are the] Rsine [differences] [for the quadrant divided into as many equal parts, each part hence being 225'] [in] minutes.
- ▶ (Circumference of the circle in minutes is $360 \times 60 = 21,600$.)

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

Beginning of calculus

- ▶ $\bar{\text{Aryabhaṭa}}$ innovation: use of numerical techniques:

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Beginning of calculus

- ▶ Āryabhaṭa innovation: use of numerical techniques:
- ▶ Āryabhaṭa (“Euler”) method to solve difference equations

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Beginning of calculus

- ▶ $\bar{\text{Aryabhaṭa}}$ innovation: use of numerical techniques:
- ▶ $\bar{\text{Aryabhaṭa}}$ (“Euler”) method to solve difference equations
- ▶ and calculate sine values accurate to the minute.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ $\bar{\text{Aryabhaṭa}}$ was criticised for using linear interpolation

- ▶ $\bar{\text{A}}\text{ryabha}\bar{\text{t}}\text{a}$ was criticised for using linear interpolation
- ▶ Brahmagupta (7th c.) used quadratic interpolation (“Stirling’s formula”)

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ $\bar{\text{A}}\text{ryabha}\bar{\text{t}}\text{a}$ was criticised for using linear interpolation
- ▶ Brahmagupta (7th c.) used quadratic interpolation (“Stirling’s formula”)
- ▶ also used by Vaṭeṣvara (9th c.) to calculate 96 sine values accurate to the seconds.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Madahava's sine values use 11th/12th order interpolation/extrapolation

- ▶ Madahava's sine values use 11th/12th order interpolation/extrapolation
- ▶ to achieve accuracy to the thirds.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ This actually involved infinite series

- ▶ This actually involved infinite series
- ▶ “Taylor’s series” for sine, cosine and arctangent

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ This actually involved infinite series
- ▶ “Taylor’s series” for sine, cosine and arctangent
- ▶ and “Leibniz” series for π .

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Sum of **infinite** geometric series

- ▶ Infinite series were summed. E.g.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Sum of infinite geometric series

- ▶ Infinite series were summed. E.g.
- ▶ first formula for sum of infinite geometric series given by 15th c. Nīlakanṭha in his commentary on *Āryabhaṭīya* (Ganita 22)

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

एवं यस्तुल्यच्छेदपरभागपरम्पराया अनन्ताया अपि संयोगः
तस्यानन्तानामपि कल्प्यमानस्य योगस्याद्यावयविनः
परम्परांशच्छेदादेकोनच्छेदांशसाम्यं सर्वत्रापि समानमेव ।

which may be translated:⁷⁵

The sum of an infinite [*anantya*] series, whose later terms (after the first) are got by dividing the preceding one by the same divisor everywhere, is equal to the first term divided by one less than the common divisor.

- ▶ Today infinite sums taught using limits

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Today infinite sums taught using limits
- ▶ (a particular metaphysics of infinity).

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Today infinite sums taught using limits
- ▶ (a particular metaphysics of infinity).
- ▶ In India they were summed differently using

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Today infinite sums taught using limits
- ▶ (a particular metaphysics of infinity).
- ▶ In India they were summed differently using
- ▶ (a) “non-Archimedean” arithmetic

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Today infinite sums taught using limits
- ▶ (a particular metaphysics of infinity).
- ▶ In India they were summed differently using
- ▶ (a) “non-Archimedean” arithmetic
- ▶ (b) discarding infinitesimals using a philosophy of inexactitude

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Today infinite sums taught using limits
- ▶ (a particular metaphysics of infinity).
- ▶ In India they were summed differently using
- ▶ (a) “non-Archimedean” arithmetic
- ▶ (b) discarding infinitesimals using a philosophy of inexactitude
- ▶ called of zeroism (*śūnyavāda*).

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ Today infinite sums taught using limits
- ▶ (a particular metaphysics of infinity).
- ▶ In India they were summed differently using
- ▶ (a) “non-Archimedean” arithmetic
- ▶ (b) discarding infinitesimals using a philosophy of inexactitude
- ▶ called of zeroism (*śūnyavāda*).
- ▶ which rejects the fantasy of exactitude at infinity as an error.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ Today infinite sums taught using limits
- ▶ (a particular metaphysics of infinity).
- ▶ In India they were summed differently using
- ▶ (a) “non-Archimedean” arithmetic
- ▶ (b) discarding infinitesimals using a philosophy of inexactitude
- ▶ called of zeroism (*śūnyavāda*).
- ▶ which rejects the fantasy of exactitude at infinity as an error.
- ▶ (If you don't understand it, you were not properly educated!)

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ Word “algebra” comes from “Al jabr waal muqabla” of 8th al Khwarizmi of Baghdad

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ Word “algebra” comes from “Al jabr waal muqabla” of 8th al Khwarizmi of Baghdad
- ▶ who translated also the work of Brahmagupta.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Word “algebra” comes from “Al jabr waal muqabla” of 8th al Khwarizmi of Baghdad
- ▶ who translated also the work of Brahmagupta.
- ▶ Brahmagupta called polynomials (such as $2x + 3$) unexpressed (“avyakt”) numbers

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ Word “algebra” comes from “Al jabr waal muqabla” of 8th al Khwarizmi of Baghdad
- ▶ who translated also the work of Brahmagupta.
- ▶ Brahmagupta called polynomials (such as $2x + 3$) unexpressed (“avyakt”) numbers
- ▶ Led to unexpressed fractions (e.g. $\frac{2x+3}{3x+4}$, or rational functions)

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ Word “algebra” comes from “Al jabr waal muqabla” of 8th al Khwarizmi of Baghdad
- ▶ who translated also the work of Brahmagupta.
- ▶ Brahmagupta called polynomials (such as $2x + 3$) unexpressed (“avyakt”) numbers
- ▶ Led to unexpressed fractions (e.g. $\frac{2x+3}{3x+4}$, or rational functions)
- ▶ which constitute what is today called a non-Archimedean ordered field.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

Better calculus

- ▶ Advocate it NOT because it is Indian in origin, but because it is BETTER.

Better calculus

- ▶ Advocate it NOT because it is Indian in origin, but because it is BETTER.
- ▶ Non-Archimedean arithmetic leads to better calculus today.

Better calculus

- ▶ Advocate it NOT because it is Indian in origin, but because it is BETTER.
- ▶ Non-Archimedean arithmetic leads to better calculus today.
- ▶ E.g. university calculus fails for discontinuous functions

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

Better calculus

- ▶ Advocate it NOT because it is Indian in origin, but because it is BETTER.
- ▶ Non-Archimedean arithmetic leads to better calculus today.
- ▶ E.g. university calculus fails for discontinuous functions
- ▶ which cannot be differentiated.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

Better calculus

- ▶ Advocate it NOT because it is Indian in origin, but because it is BETTER.
- ▶ **Non-Archimedean arithmetic leads to better calculus today.**
- ▶ E.g. university calculus fails for discontinuous functions
- ▶ which cannot be differentiated.
- ▶ But shocks are discontinuities which commonly arise.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

Better calculus

- ▶ Advocate it NOT because it is Indian in origin, but because it is BETTER.
- ▶ Non-Archimedean arithmetic leads to better calculus today.
- ▶ E.g. university calculus fails for discontinuous functions
- ▶ which cannot be differentiated.
- ▶ But shocks are discontinuities which commonly arise.
- ▶ How to make sense of the nonlinear partial differential equations of physics when there is a discontinuity?

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ University calculus is replaced at an advanced level by Schwartz distributions, or generalised functions.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ University calculus is replaced at an advanced level by Schwartz distributions, or generalised functions.
- ▶ This linear theory also fails for shocks (since the equations of physics are non-linear).

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ University calculus is replaced at an advanced level by Schwartz distributions, or generalised functions.
- ▶ This linear theory also fails for shocks (since the equations of physics are non-linear).
- ▶ The solution involved Non-Standard Analysis

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ University calculus is replaced at an advanced level by Schwartz distributions, or generalised functions.
- ▶ This linear theory also fails for shocks (since the equations of physics are non-linear).
- ▶ The solution involved Non-Standard Analysis
- ▶ but the only aspect required is non-Archimedean arithmetic and a philosophy of discarding infinitesimals.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

Decolonised calculus

- ▶ To summarise: decolonised calculus involves 3 major changes

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Decolonised calculus

- ▶ To summarise: decolonised calculus involves 3 major changes
- ▶ Teach calculus as the numerical solution of differential equations.

Decolonised calculus

- ▶ To summarise: decolonised calculus involves 3 major changes
- ▶ Teach calculus as the numerical solution of differential equations.
- ▶ Sum infinite series using non-Archimedean arithmetic (no limits).

Decolonised calculus

- ▶ To summarise: decolonised calculus involves 3 major changes
- ▶ Teach calculus as the numerical solution of differential equations.
- ▶ Sum infinite series using non-Archimedean arithmetic (no limits).
- ▶ Teach zeroism (a philosophy of inexactitude).

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

Advantages

- ▶ Advantages:

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Advantages

- ▶ Advantages:
- ▶ Makes calculus easy.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Advantages

- ▶ Advantages:
- ▶ Makes calculus easy.
- ▶ Conceptual clarity

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Advantages

- ▶ Advantages:
- ▶ Makes calculus easy.
- ▶ Conceptual clarity
- ▶ Ability to solve harder problems (such as elliptic integrals)

Advantages

- ▶ Advantages:
- ▶ Makes calculus easy.
- ▶ Conceptual clarity
- ▶ Ability to solve harder problems (such as elliptic integrals)
- ▶ Better science.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Results

- ▶ Experiment performed with 1 group in Central University of Tibetan Studies, Benaras

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ Experiment performed with 1 group in Central University of Tibetan Studies, Benaras
- ▶ 4 groups in Universiti Sains Malaysia, Penang

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Experiment performed with 1 group in Central University of Tibetan Studies, Benaras
- ▶ 4 groups in Universiti Sains Malaysia, Penang
- ▶ social science students in Ambedkar University, Delhi

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Experiment performed with 1 group in Central University of Tibetan Studies, Benaras
- ▶ 4 groups in Universiti Sains Malaysia, Penang
- ▶ social science students in Ambedkar University, Delhi
- ▶ and in CISSC Tehran.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Experiment performed with 1 group in Central University of Tibetan Studies, Benaras
- ▶ 4 groups in Universiti Sains Malaysia, Penang
- ▶ social science students in Ambedkar University, Delhi
- ▶ and in CISSC Tehran.
- ▶ Running as a regular course in SGT University, Delhi (72 students).

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Conceptual confusion about calculus among most students.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Conceptual confusion about calculus among most students.
- ▶ Most flunk the pre-test

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ Conceptual confusion about calculus among most students.
- ▶ Most flunk the pre-test
- ▶ (even PG students, half of whom hence dropped out).

SGT University: calculus without limits

Pre-test

Answer all questions.

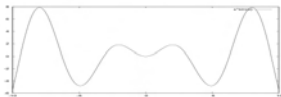
Blank answer fetches 0. Wrong answer gets negative marks.

Classes refer to NCERT texts. You may have learnt from a different text in school.

- 1. Points.** You were taught about points in class VI.
 - (a) Define a point.
 - (b) What is the size of a point?
 - (c) Can something with no size be seen? If something is invisible, how do you know where it is?
 - (d) What is the difference between a fraction and a rational number?
- 2. Numbers.** You were taught "real" numbers in class IX and class X.
 - (a) Define a real number.
 - (b) Write down the EXACT value of $\sqrt{2}$. If x is that exact value, show by direct calculation that $x^2=2$. (Note: this should not be 1.999999999, but exactly 2.)
 - (c) Can a complex number be written as the ratio of two integers? If i is the complex number such that $i^2=-1$ then is i irrational? Is it rational?
 - (d) Are there numbers which are neither rational nor irrational? If your answer is yes, go back and re-check your definition at (a). If your answer is no, explain how -1 can have a real square root.
- 3. Sets.** You were taught about sets in class X.
 - (a) Define a set.
 - (b) If you defined a set as a "collection of objects", define "collection" and define "object". Is "object" the same as in object-oriented programming? If not, what is the difference?
 - (c) Let $R = \{x \mid x \notin x\}$. Is it true that $R \in R$? Is it true that $R \notin R$?
 - (d) Can a set have an infinite number of elements? How can you be sure?
- 4. Trigonometry.** You were taught about trigonometric functions in class IX.
 - (a) Define $\sin(x)$.
 - (b) Use that definition to calculate $\sin(0.3^\circ)$.
 - (c) Is $\sin(92^\circ)$ defined? According to my calculator, $\sin(92^\circ) = 0.9993$. Is this right? Explain.
 - (d) Define a radian. Exactly how many degrees is 1 radian?
- 5. Limits.** You were taught about limits in class XI and XII.
 - (a) Define limit.
 - (b) According to my calculator $\sqrt{2} = 1.4142135623730950488016887242097$. Does the sequence 1, 1.4, 1.41, 1.414, 1.414... have a limit?
 - (c) What is the infinite sum of all natural numbers, $1+2+3+4+\dots$? Can it be a negative number?
 - (d) What is the infinite sum $1-1+1-1+1-1+\dots$?
- 6. Derivative.** You were taught about derivatives in class XI and XII.
 - (a) Define the derivative of a function.
 - (b) Let \mathbb{N} denote the set of natural numbers, and let $f: \mathbb{N} \rightarrow \mathbb{N}$ be given by $f(x)=x^2$.

What is the derivative of f ?

(c) Define the tangent to a curve at a point. Consider the function $x \sin(x)$ whose graph is



displayed. Write the equation of the tangent to the curve at $x=0$. At how many points does this line intersect the curve? Can you list these points?

(d) What is the derivative of $\operatorname{atanh}(x)$ (hyperbolic arc tangent) with respect to x ?

7. **Integral.** You were taught about integrals in class XII.

(a) Define the integral of a function.

(b) Shown below is a piece of land with irregular boundaries. How will you calculate its area?



(c) Calculate $\int_{-1}^{-2} \frac{dx}{x}$.

(d) Calculate $\int \frac{1}{\sqrt{(1-x^2)(1-4x^2)}} dx$.

8. **Applications.** You learnt about Newton's laws of motion and the simple pendulum from class VIII to class XI.

(a) At approximately what angle should you throw a cricket ball so that it travels the furthest distance?

(b) Will the answer change if you use a tennis ball instead of a cricket ball?

(c) The formula for the time period of a simple pendulum is $T = 2\pi\sqrt{\frac{l}{g}}$. Therefore, the time period of a simple pendulum is independent of amplitude. Is this true or false?

(d) Did you ever experimentally verify any of your answers above?

Math Group: Calculus without Limits
Exam, Pre-test: **A**

Name: _____

Student Number: _____

Course: _____

Age: _____

Date: _____

- Please attach this question paper and return it along with your answer sheet.
 - This is not a competitive test. The aim is to obtain feedback to decide what to teach and how.
 - Since the group is heterogeneous, you may find some questions too easy, or some may be too difficult. Attempt as many questions as you are able to.
1. (a) Define a complete metric space.
(b) The least upper bound property for \mathbb{R} says that if $A \subset \mathbb{R}$ is non-empty and bounded above, then $\exists \alpha \in \mathbb{R}$ such that $a \leq \alpha$, $\forall a \in A$, and if $a \leq b$, $\forall a \in A$ then $\alpha \leq b$. Assume the least upper bound property and prove that \mathbb{R} is a complete metric space.
 2. (a) Define “infinite set”, “countable set”, “uncountable set”.
(b) Prove that \mathbb{R} is uncountable.
(c) If \mathbb{N} is the set of natural numbers, and $P(\mathbb{N})$ is its power set, does there exist a bijective map $f: P(\mathbb{N}) \rightarrow \mathbb{R}$?
 3. (a) Write down the binary representation of 41.
(b) Write down the binary representation of 2.5
(c) Rewrite your answer using a mantissa between 1 and 2.
 4. Given $g(x) = \begin{cases} x^2 - C, & \text{if } x < 4 \\ -\sqrt{C}x + 20, & \text{if } x \geq 4 \end{cases}$
(a) Find the value of C which makes g continuous on $(-\infty, \infty)$.
(b) With the above value of C , is g differentiable? Explain your answer.
 5. (a) Suppose f_n is a sequence of Riemann integrable functions which converges to the function f on $(0, \infty)$, convergence being uniform on compact subsets. Is it true that f is Riemann integrable and that $\int_0^\infty f_n \rightarrow \int_0^\infty f$?
(b) Suppose f_n is a sequence of differentiable functions which converges uniformly to the function f on $(0, 1)$. Is it true that f is differentiable and that the sequence of derivatives $f_n' \rightarrow f'$?

6. (a) Give an example of a real-valued function f which is not Riemann integrable on $[0, 1]$. Is this Lebesgue integrable?
- (b) Does there exist a Riemann integrable function on $(0, \infty)$ which is not Lebesgue integrable?
7. The following ten numbers were drawn at random from $[0, 1]$ using a uniform probability distribution: 0.23, 0.74, 0.18, 0.79, 0.51, 0.34, 0.67, 0.44, 0.11, 0.44.
- (a) Find the average.
- (b) Explain why it is not 0.5.
- (c) If the average does equal 0.5 at some stage, can subsequent draws of further random numbers change that value?
- (d) An unbiased coin is tossed 100 times. The first toss is tails, and the subsequent 99 tosses are heads. At the 101st toss (i) is the probability of tails greater than that of heads or (ii) is the probability of heads greater than that of tails?
8. Suppose a monkey is typing at random on a typewriter which has 50 keys (x and Z having been dropped), and suppose that the monkey is equally likely to strike any key.
- (a) What is the probability that the first six letters the monkey types will spell the word "Hamlet".
- (b) Suppose we consider the letters typed by the monkey in consecutive blocks of six letters. What is the probability p_n that the first n blocks of six letters will have the word "Hamlet"?
- (c) Does $\lim_{n \rightarrow \infty} p_n$ exist? If so, what is it?
9. Differentiate the following with respect to x
- (a) $\sin^n x \cdot \sin nx$
- (b) $\sec^{-1} \frac{\sqrt{x}+1}{\sqrt{x}-1} + \sin^{-1} \frac{\sqrt{x}-1}{\sqrt{x}+1}$
- (c) $x - \log(2e^x + 1 + \sqrt{e^{2x} + 4e^x + 1})$
10. Evaluate the following indefinite integrals.
- (a) $\int \sqrt{3x+2} \, dx$
- (b) $\int \log x \, dx$
- (c) $\int \frac{dx}{\sqrt{\sin^3 x \cdot \sin(x+\alpha)}}$

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ In contrast, in calculus without limits

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ In contrast, in calculus without limits
- ▶ within a few days they could manage hard problems

- ▶ In contrast, in calculus without limits
- ▶ within a few days they could manage hard problems
- ▶ and most found the post-test very easy.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Tutorial

Calculus without Limits

I: Differentiation

Differentiate the following functions with respect to x .

1. $x^2 e^{\sqrt{x}}$.

2. $\cosh^{-1}(x)$

3. $\log \sqrt{\frac{1+x \cos x}{1-x \cos x}}$

4. $\tan^{-1}\left(\frac{e^{2x}+1}{e^{2x}-1}\right)$

II: Integration

Evaluate the following integrals.

5.

$$\int \frac{\sqrt{x}-\sqrt{x}}{1-\sqrt{2x}} dx$$

6.

$$\int \sec^{-1} \sqrt{x} dx$$

7.

$$\int \cot^5 x dx$$

8.

$$\int_0^{0.5} \frac{1}{\sqrt{1-x^2}\sqrt{1-x}} dx$$

III : Ordinary differential equations

9. Duffing's equation

$$\frac{d^2x}{dt^2} + b\frac{dx}{dt} - x + x^3 = a \cos(ct)$$

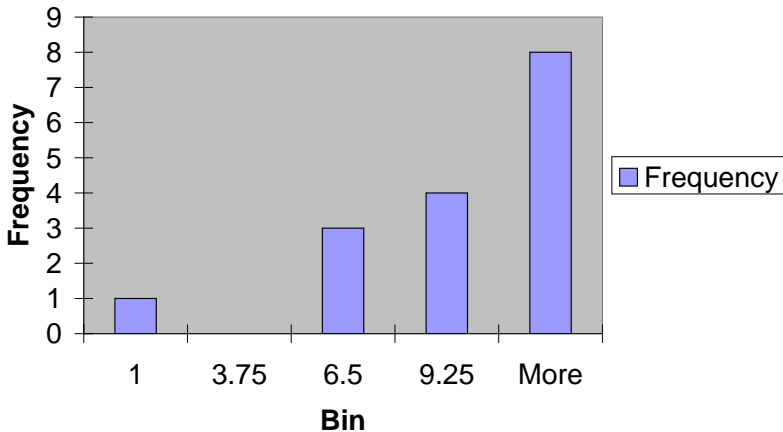
represents a particle in a quartic potential, driven harmonically. Solve this equation with the initial data $x(0) = 0$, $x'(0) = 1$. Obtain the values of the first six zeros. Is the solution periodic?

10. Solve van der Pol's equation

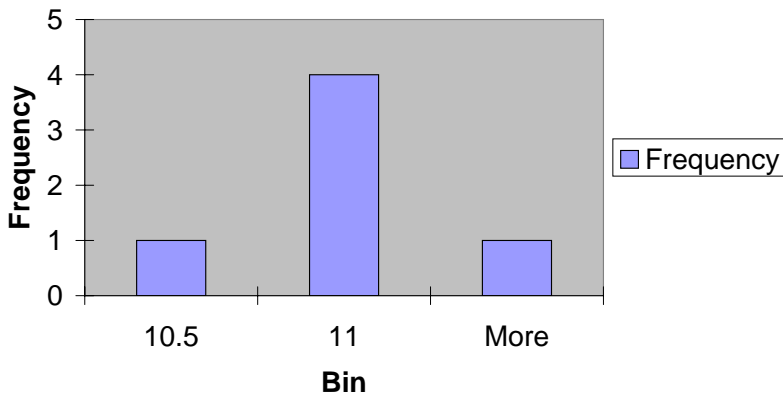
$$y'' + (y^2 - 1)y' + y = 0,$$

with $y(0) = 2$, $y'(0) = 0$, and find the value of the first x for which y has a local maximum.

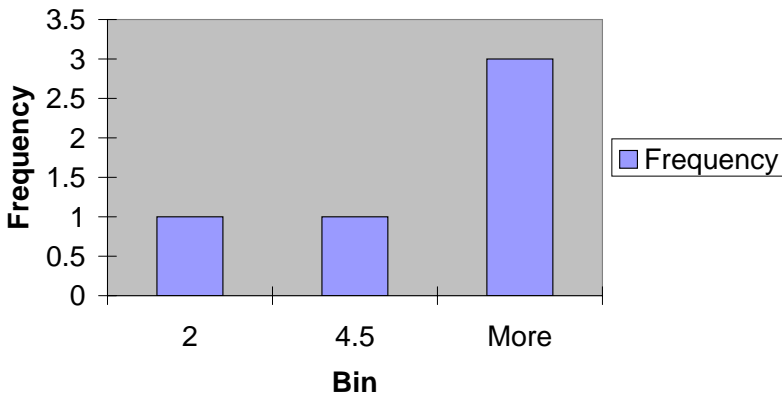
PG Post Test



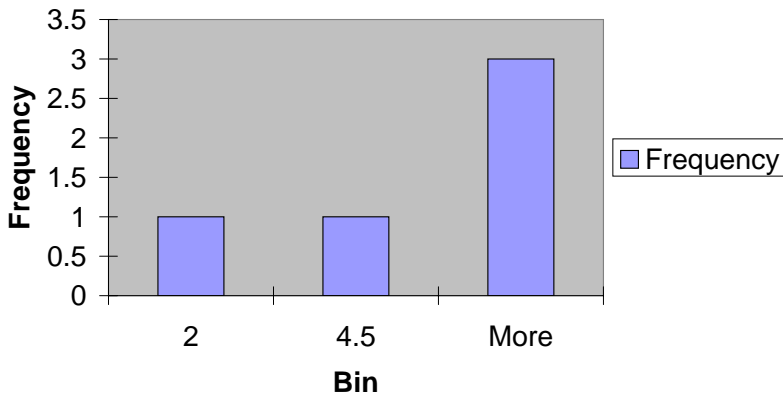
UG App Math max marks 12



UG pure math max marks 7



Non-math max marks 7



Central University, Sarnath



Decolonising
Math and
Science
Education

C. K. Raju

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion



نشست علمی "ریاضیات از منظری دیگر"، پروفیسور سی.کی. راجو
مرکز مطالعات و همکاری های علمی بین المللی، تهران، ۱۳۹۱

Ambedkar University, Delhi



Decolonising Math and Science Education

C. K. Raju

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion



Decolonising science

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

**Decolonising
science**

Other
decolonised
courses

Conclusion

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

**Decolonising
science**

Other
decolonised
courses

Conclusion

- ▶ Education is interconnected.

- ▶ Education is interconnected.
- ▶ Changing the understanding and teaching of calculus

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

**Decolonising
science**

Other
decolonised
courses

Conclusion

- ▶ Education is interconnected.
- ▶ Changing the understanding and teaching of calculus
- ▶ means science must change.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

**Decolonising
science**

Other
decolonised
courses

Conclusion

- ▶ Education is interconnected.
- ▶ Changing the understanding and teaching of calculus
- ▶ means science must change.
- ▶ (No more tricks like Hawking and Tipler)

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

**Decolonising
science**

Other
decolonised
courses

Conclusion

- ▶ No more church dogmas of “laws of nature” in science

- ▶ No more church dogmas of “laws of nature” in science
- ▶ as in “Newton’s laws of motion” or “Universal law of gravitation”

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

**Decolonising
science**

Other
decolonised
courses

Conclusion

- ▶ It also means the history and philosophy of science must change

- ▶ It also means the history and philosophy of science must change
- ▶ Real story: Newton and Leibniz did not invent calculus

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

**Decolonising
science**

Other
decolonised
courses

Conclusion

- ▶ It also means the history and philosophy of science must change
- ▶ Real story: Newton and Leibniz did not invent calculus
- ▶ they did not even understand it properly.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

**Decolonising
science**

Other
decolonised
courses

Conclusion

- ▶ It also means the history and philosophy of science must change
- ▶ Real story: Newton and Leibniz did not invent calculus
- ▶ they did not even understand it properly.
- ▶ Hence Newtonian physics failed.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

**Decolonising
science**

Other
decolonised
courses

Conclusion

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

**Decolonising
science**

Other
decolonised
courses

Conclusion

- ▶ Correcting the Western misunderstanding of calculus corrects Newtonian gravitation

- ▶ Correcting the Western misunderstanding of calculus corrects Newtonian gravitation
- ▶ as in my retarded gravitation theory.

- ▶ Better skills at calculus leads to better science teaching.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

**Decolonising
science**

Other
decolonised
courses

Conclusion

- ▶ Better skills at calculus leads to better science teaching.
- ▶ The simple pendulum is the first serious science experiment

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ Better skills at calculus leads to better science teaching.
- ▶ The simple pendulum is the first serious science experiment
- ▶ but calculating its time period requires the ability to deal with elliptic integrals.

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ Better skills at calculus leads to better science teaching.
- ▶ The simple pendulum is the first serious science experiment
- ▶ but calculating its time period requires the ability to deal with elliptic integrals.
- ▶ (That is why my software CALCODE was developed—to teach my children science.)

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

**Other
decolonised
courses**

Conclusion

Other decolonised courses

- ▶ Other decolonised courses

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

**Other
decolonised
courses**

Conclusion

- ▶ Other decolonised courses
- ▶ On history and philosophy of science (taught at AlBukhary International University several times)

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

**Other
decolonised
courses**

Conclusion

- ▶ Other decolonised courses
- ▶ On history and philosophy of science (taught at AlBukhary International University several times)
- ▶ and Egyptian/Indian cord geometry (being tried out with school children in India).

- ▶ Other decolonised courses
- ▶ On history and philosophy of science (taught at AlBukhary International University several times)
- ▶ and Egyptian/Indian cord geometry (being tried out with school children in India).
- ▶ No time for details: will just show you some pictures.



Measuring the earth

Decolonising
Math and
Science
Education





Further questions

- Is it ethical to perform drug trials without informed consent?
- Is it ethical to locate a nuclear reactor in a big city without the informed consent of the people? (E.g. nuclear reactor at Trombay, in Mumbai)
- Is it ethical to watch something unethical happening and do nothing about it?
- The list goes on
- (and you will see more of it in the examination!)

Faculty and
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HPS-2

Even after the university closed

Decolonising
Math and
Science
Education

C. K. Raju



- ▶ Similarly backward integration with Egyptian/African cord geometry in schools

Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ Similarly backward integration with Egyptian/African cord geometry in schools
- ▶ (not because it is indigenous, but because it is better).

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Introduction

Normal math vs formal math

Colonial education and colonialism

Myths and superstitions of formal math

The alternative

Results

Decolonising science

Other decolonised courses

Conclusion

- ▶ Similarly backward integration with Egyptian/African cord geometry in schools
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Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

**Other
decolonised
courses**

Conclusion

- ▶ Compass box inferior: has no instrument with which to measure a curved line.
- ▶ Teaching cord geometry leads to
- ▶ conceptual clarify about point, angle, arc, etc.
- ▶ Teachers accept conceptual confusion during workshop

Home assignment

The proposed workshop will teach participants about five different types of geometry.

1. Hilbert's synthetic geometry.
2. Birkhoff's axiomatic metric geometry.
3. "Euclidean" geometry.
4. Compass box (empirical) metric geometry
5. The geometry of the sulba sutra.

The reading list for this is put up at <http://ckraju.net/geometry/Reading-list-geometry.html>.

The same open directory (<http://ckraju.net/geometry/>) also has (a) the original book by Hilbert on synthetic geometry (<http://ckraju.net/geometry/Hilbert-Foundations-of-Geometry.pdf>), (b) the original paper by Birkhoff on axiomatic metric geometry (http://ckraju.net/geometry/1932_Birkhoff.pdf), (c) Bertrand Russell's original critique of "Euclidean" geometry (<http://ckraju.net/geometry/Bertrand%20Russell%20on%20Euclid.htm>), and (d) The Manava sulba-sutra, in the original Sanskrit (http://ckraju.net/geometry/manava_shulba_sutra.pdf). An English translation of a key verse (Manava 10.10) from the book by Sen and Bag is also put up online in the same directory (<http://ckraju.net/geometry/translation-Manava-10.10.pdf>). There is also a detailed critique of geometry in NCERT school texts, class 6-9 in the same directory (<http://ckraju.net/geometry/NCERT%20critique-and-outline-of-alternative.pdf>) which critique will be covered during the workshop.

Please glance through these references, (You are not expected to fully understand these references; it is the purpose of the workshop to help you understand them, and the key differences between these different types of geometry.) But try to answer the following preliminary questions.

1. (a) Is the length of a line segment defined in Hilbert's synthetic geometry? If so, from what axioms?
(b) Is Hilbert's notion of congruence of triangles the same as the equality of two triangles?
2. Why, in your opinion, is the proof of "Pythagorean" proposition so easy in Birkhoff's geometry, when it requires a whole book in "Euclidean" geometry?
3. (a) Why is the proof of the first proposition of "Euclidean" geometry wrong according to Russell?
(b) Does this mean that the proof of the "Pythagorean" theorem in "Euclidean" geometry is also wrong?
4. The length of a line segment can be easily measured using a ruler in the compass box. Does this differ from the way the length of a line segment is defined in Birkhoff's metric geometry? If so, how?
5. (a) Is the statement in Manava 10.10 equivalent to the "Pythagorean" theorem?
(b) If not, what is the difference? (Hint: read the last part of my article "Black thoughts matter: decolonized math, academic censorship, and the "Pythagorean" proposition" in *Journal of Black Studies*, online first, 31 Jan 2017. The article can be downloaded from the publishers site (<http://journals.sagepub.com/doi/pdf/10.1177/0021934716688311>). [Do not subsequently upload this article to other websites, always use the above link.]
6. (a) Which of the above geometries are included in your school texts? which are excluded? Why?
(b) Does the school text explain the difference between the various types of geometry that are included? Are they all mutually compatible?





Gundlupete

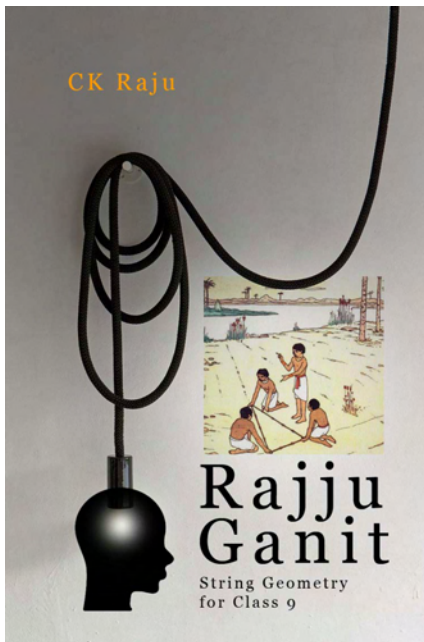
Repeat workshop

Decolonising
Math and
Science
Education

C. K. Raju



The textbook



Decolonising
Math and
Science
Education

C. K. Raju

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

Conclusion

- ▶ Ample material for decolonised courses available.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Ample material for decolonised courses available.
- ▶ You must decide whether to use it.

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Ample material for decolonised courses available.
- ▶ You must decide whether to use it.
- ▶ You choose whether academics remain subordinate to the West

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ Ample material for decolonised courses available.
- ▶ You must decide whether to use it.
- ▶ You choose whether academics remain subordinate to the West
- ▶ and creates indoctrinated slave minds.

- ▶ You have time

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion

- ▶ You have time
- ▶ until the students again revolt and burn down the university!

Introduction

Normal math vs
formal math

Colonial
education and
colonialism

Myths and
superstitions of
formal math

The alternative

Results

Decolonising
science

Other
decolonised
courses

Conclusion