Summer School Versus Term-Time for Fundamental Mathematics at the Tertiary Level

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Introduction

Term-time:

- 17 weeks, two semesters per year (Mar—Jul, Aug—Nov).
- Breakdown: 13 weeks of classes, 2 weeks of breaks, 2 exam weeks.

Summer School:

- 7 weeks intensive program from Jan-Feb.
- Breakdown: 6 weeks of classes, 1 exam week.

Bottom line:

Same material squeezed into less than half the time!

Introduction

- **Summer School:** ***Superior learning outcomes?***

- Maths/stats is **mandatory** for Science students at Sydney, which can be problematic for students with weak backgrounds. Some fail to pass (pun intended).

- **Focus for our study:** the **Fundamental-Level** units
  - Assumed-knowledge is *2-Unit HSC Mathematics (or equivalent).*
  - Two core fundamental units
    - **MATH1011:** Applications of Calculus (Semester 1)
    - **MATH1013:** Mathematical Modelling (Semester 2)

- ***Repeating*** students: should they choose **Term-time** or **Summer School**?

Pedagogical benefits of Summer School

- **Characteristics of the course or learning environment**

  intensive schedule; smaller cohort; smaller tutorials;
  sensitivity to weaker students

- **Teacher's approach to teaching and learning**

  experience; enthusiasm;
  higher degree of connection between staff and students

- **Student characteristics and approaches**

  motivation; enthusiasm; focus

Do these hypothesised benefits of Summer School translate to superior learning outcomes?

THE EVIDENCE: SURVEYS

Unit of Study Evaluations (USE)

"I found Summer School MATH1011 very much more enjoyable and productive than during [term-time]."

"Made maths much easier to understand. Much easier than normal semester."

"I felt that tutorials were more friendly and more helpful than the tutorials in normal semester."

"[The Summer School lecturer] should take the Semester 1 class as well as Summer School."

"So much easier & more enjoyable at Summer School."

"Having failed this course once, I feared I would not be as motivated as I was, however the teaching enthusiasm and pace were great motivations to learn."

"Summer math courses have a shorter span – 6 weeks rather than 13 weeks [with] the same amount of teaching time, things remain fresh."

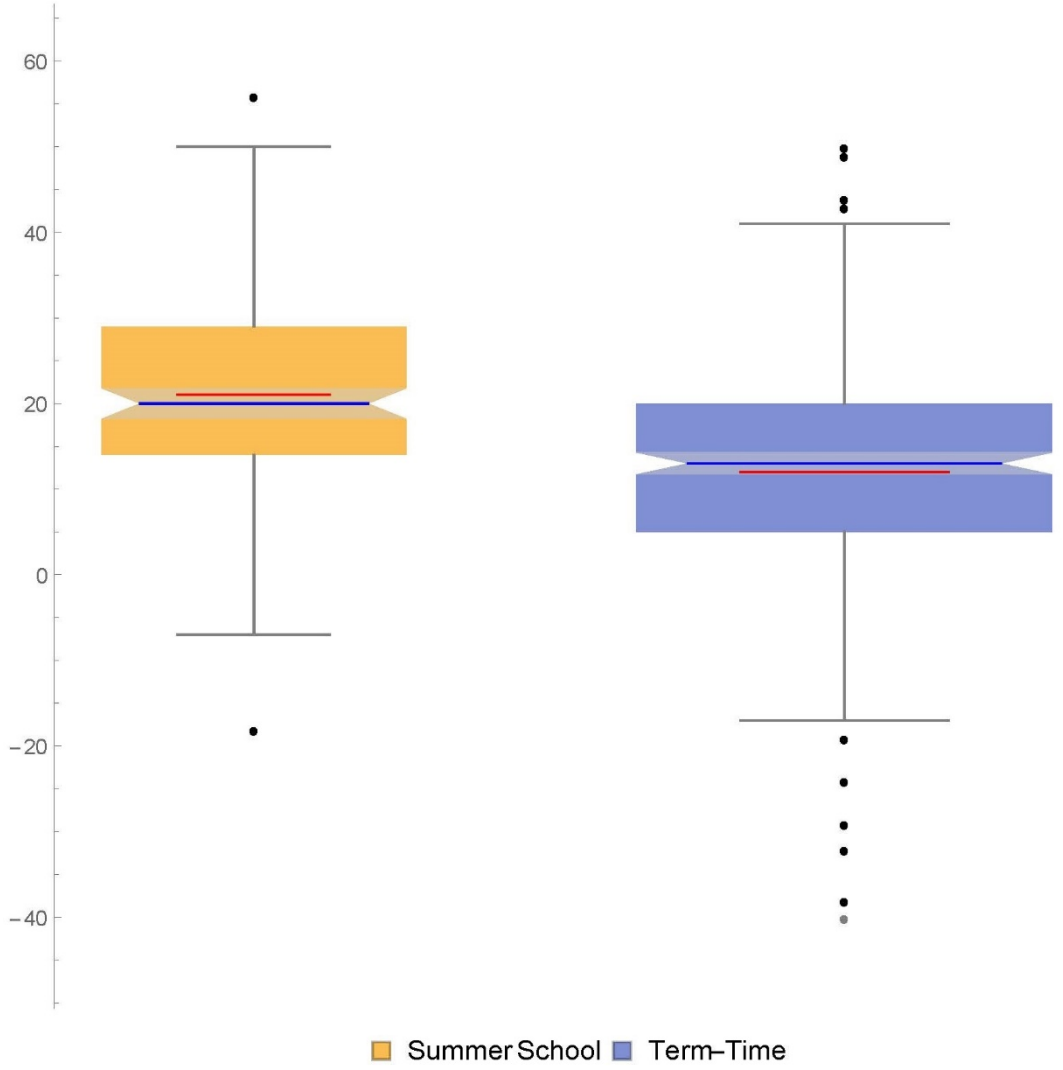
Summer School repeaters reveal astonishingly high median increases in their final marks.

FINAL MARKS

Statistical Analysis: Method

- Extract data from fundamental math students that fail in term-time that subsequently repeat later on.
- Separate into two groups: repeat during term-time, repeat at Summer School.
- Calculate the numerical difference of final marks of two nearest/adjacent attempts at the same unit of study.
- We are interested in comparing the *medians* of the increases.
- Compare statistics of Summer School vs. term-time median differences over several years (data ranging from 2006-2014).
- Exclude if received ‘absent fail’ grade or absent from final exam.
- Use Mann-Whitney to test statistical significance of difference of medians.

Statistical Analysis: Results!



	Number	Median	Mean	IQR
Summer School	177	20	21	15
Term – time	332	13	12	15

Statistical Analysis: Results!

By inspection we can reasonably suggest that summer school repetition results in a much higher increase than term-time!

<u>Testing Statistical Significance: Mann-Whitney</u>

- $H_0: \widetilde{SS} \leq \widetilde{TT}$
- $H_1: \widetilde{SS} > \widetilde{TT}$
- Statistic = 40757
- P-value = 2.98649×10^{-13}
- Cannot reject H_1

Therefore (extremely) statistically significant increase!

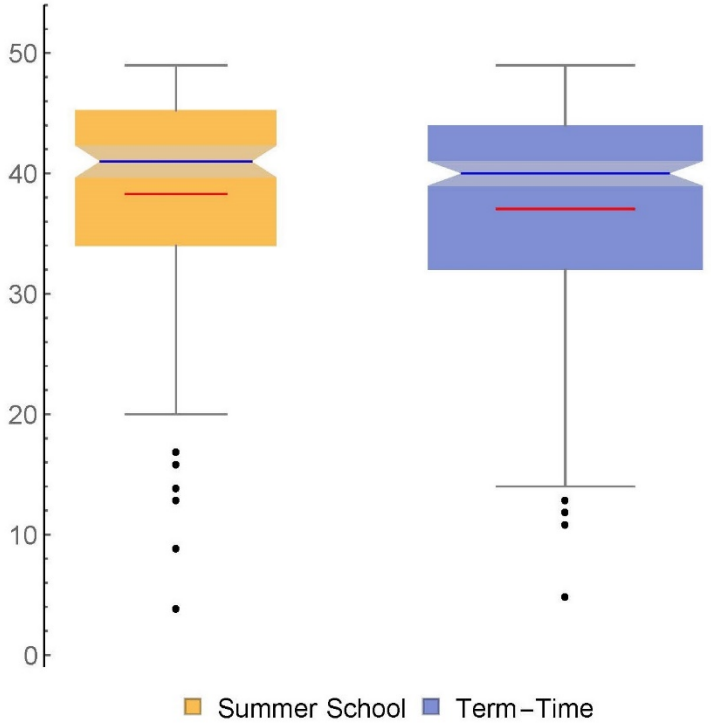
But, there's always a catch…

TWO QUESTIONS TO PONDER

Are Summer School enrolled repeating students 'smarter'?

Maybe… the median initial fail marks for summer school students may potentially be *statistically* significantly higher than their term-time counterparts.

Are Summer School enrolled repeating students ‘smarter’?



	Number	Mean	1st Quartile	Median	3rd Quartile	IQR
Summer School	177	38	34	41	45	11
Term–time	332	37	32	40	44	12

Are Summer School enrolled repeating students ‘smarter’?

- $H_0: \widetilde{SS} \leq \widetilde{TT}$
- $H_1: \widetilde{SS} > \widetilde{TT}$
- Statistic = 31928
- P-value = 0.0533 (was ≈0.07 before)
- Cannot reject H_1

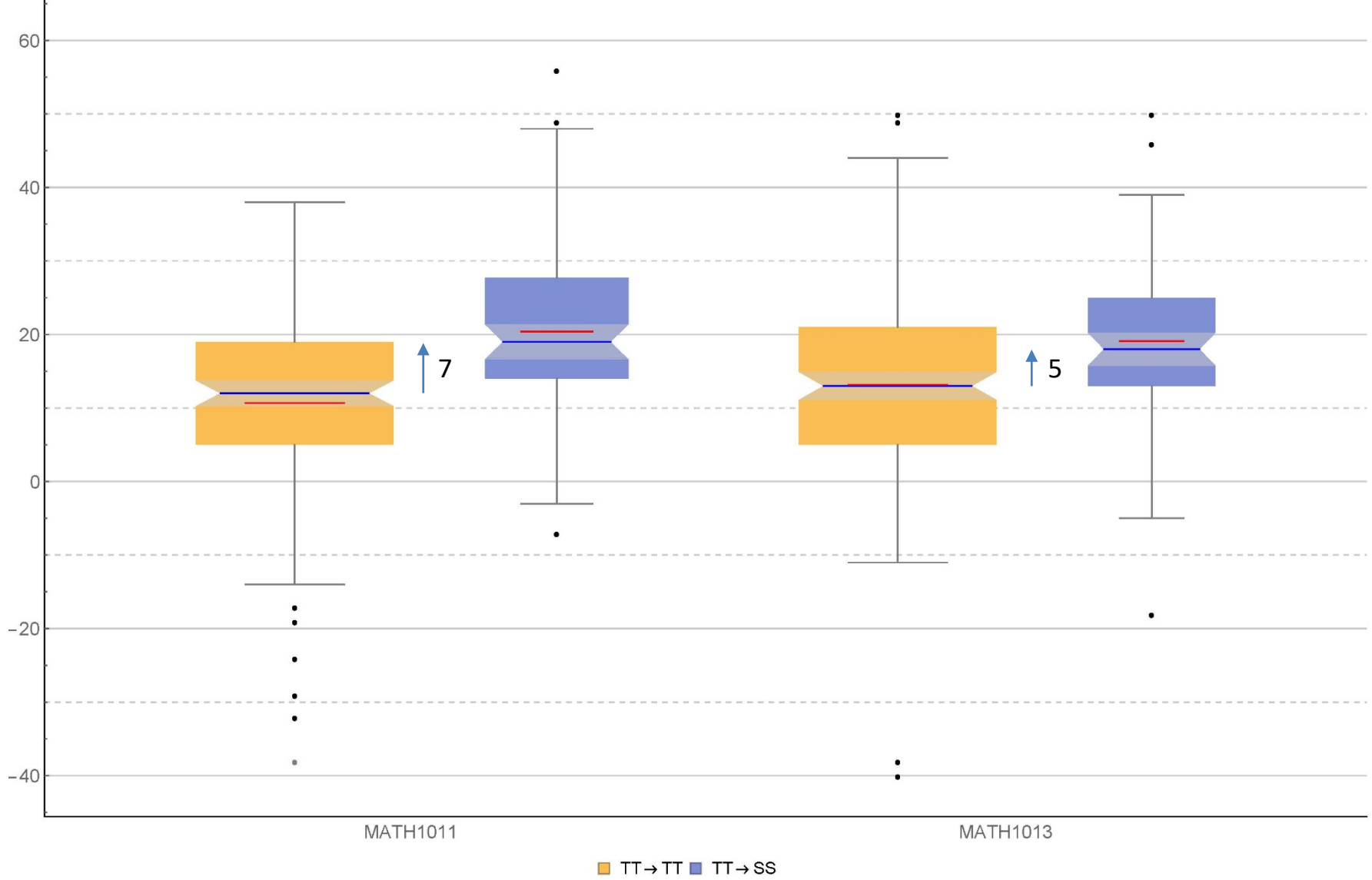
Inconclusive, but we suspect the P-value will reduce with additional data.

Do lecturer-controlled factors contribute to this phenomenon?

Probably…

Criticism: *"MATH1011 has changed significantly so as to make the unit easier for students to pass."*

We now examine the data *individually*: median increases for repeating students – SS vs. TT for both MATH1011 and MATH1013 separated.



	Number	Median	Mean	IQR
MATH1011 TT → TT	158	12	11	14
MATH1011 TT → SS	83	19	20	14
MATH1013 TT → TT	174	13	13	16
MATH1013 TT → SS	72	18	19	12

Do lecturer-controlled factors contribute to this phenomenon?

- When comparing term-time to Summer School units:
  - MATH1011 (changed significantly)
  - MATH1013 (remained largely identical)
- Compare difference of median increases:
  - $\Delta\widetilde{SS}_{1011} = 7$
  - $\Delta\widetilde{SS}_{1013} = 5$
- Also observe the shifts in skewness: distribution transformations are not statistically similar.
- *But* both still exhibit large median increases over their equivalent term−time repetitions.
- Thus assessment, structure, syllabus etc. do play a role, but they're not the dominating factors.

How do the theories of threshold concepts, constructive alignment and the SOLO taxonomy shed light on the Summer School versus term-time phenomenon?

DISCUSSION OF PEDAGOGICAL THEORIES

Threshold Concepts

- Summer repeaters exhibit more ‘momentum’ through threshold barriers beyond initial liminal confusions. Term-time repeaters have little momentum and remain within sight of liminal space.
- The fast pace of Summer School may be what gives these students the ‘momentum’ through several threshold concepts in succession.
- Term-time repeaters fail ‘worse’ than Summer School repeaters – the former sit within liminal space, the latter on the cusp of discovery.

Constructive Alignment

- Summer School format ideal for constant reinforcement.
- High level of autonomy available to Summer School lecturers; lesson structure favourable for ‘constructive alignment’.
- Lecturers have freedom to structure teaching time and allocate different TLAs ‘on the fly’; accommodate to students’ needs.

SOLO Taxonomy

- First attempt fails: students begin with ‘pre-structural’ or ‘uni-structural’ knowledge at best.
- Term-time repetition median increase of 13: often just *one* grade. Students unlikely to move far beyond uni-structural knowledge.
- Summer School repetition median increase of 20: often *two* grades! Students easily move into multi-structural level of understanding.

Stay tuned! In the next exciting episode…

FURTHER RESEARCH

- Publication of these results
- Student surveys with follow-up interviews
- Perform the same analyses with other groups of students:
  - ‘Normal-level’
  - Second-year

“If we have seen farther it is by standing on the shoulders of giants”

Special thanks go to the following at USYD:

- David Easdown – Director of 1st year studies and Summer School coordinator
- Jackie Nicholas – Head, Mathematics Learning Centre
- The School of Mathematics and Statistics
- Sydney University Human Ethics Approval
  - Project #: 2012/263
  - Reference #: 07-2009/11959

Extra bed-time reading…

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Thanks, that's all folks! ☺

Survey question:

*"What aspects of **Applications of Calculus** need improvement?"*

Student response:

"Less calculus."