The Moore Method in the U.K.: IBL at Birmingham

Chris Good, Chris Sangwin, Matthew Badger

School of Mathematics
University of Birmingham

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Acknowledgements

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Russell Group, top 20 out of 80 universities.

- Final year at (high) school: 3 ‘A’ Levels
- Grades: A^* (from 2010), A, B, C, (D, E)
- Maths ‘A’ Level: Pre-calculus, calculus, + stats or mechanics or discrete maths
- Further Maths ‘A’ Level: more calculus, matrices, complex numbers, stats, mechanics, discrete maths

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- $\approx$ 77K take A Level Maths, 44% get an A
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University of Birmingham, U.K.

University applications process

- Each applicant applies to up to 5 universities
- At Birmingham we ask for
  - *AAA* with *A* in Maths, or
  - *AAB* with F. Maths
- 1300 SAT + AP Calculus AB at 4/5 (subject requirement) + 2 other APs ($\approx$ *AAA* at A-level).
- $\approx$ 1000 applications for $\approx$ 200 places
- Students choose degree programme (major) on application
- Programmes: 180 students on Single Honours Mathematics (3yr and 4yr); Maths Majors (2/3 Maths, 1/3 other); Joints Honours (eg Maths and Computer Science)

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Programme Structure

- 120 credits in 10 credit blocks
- 100 credits passed at 40% to progress to Yr2
- Content of year 1
  - Calculus (up to integration and ODEs)
  - Linear Algebra
  - Abstract Algebra (up to the definition of a group)
  - Sequences and Series
  - Mechanics
  - Statistics
  - Discrete Maths
  - Numerics
  - **MOMD**
- 1st yr Calculus and Linear Algebra lectures $\approx$ 250 students
- Examples classes 15 to 30 students

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Issues particular to the U.K.

- Students choose their major *on application at age 17*. They are “trapped".
- Lectures not section teaching: cost of teaching so intensively.
- Curriculum includes teaching and assessment style. Change needs approval.
- Emphasis on internal and external quality assurance.
- Greater emphasis on uniformity of assessment than in US.

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Course setup

- Quite close to Moore Method in structure.
- Aim is to develop problem solving and raise confidence, not to “cover stuff".
- Set up by Chris Good in 2004
  Point set topology (3 years)
- Taken over by Chris Sangwin in 2007
  Geometry (4 years)
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Programme structure and assessment

Students take 120 credits per year.

This course is 20 credits, split over two semesters.

- Semester 1 traditional geometry course.
- Semester 2 Moore method course.

- Quality of best 2 presentations 13%
- Individual written solutions to all problems 12%
- Examination 25%
- (Semester 1 *"Formal Euclidean Geometry"* 50%).

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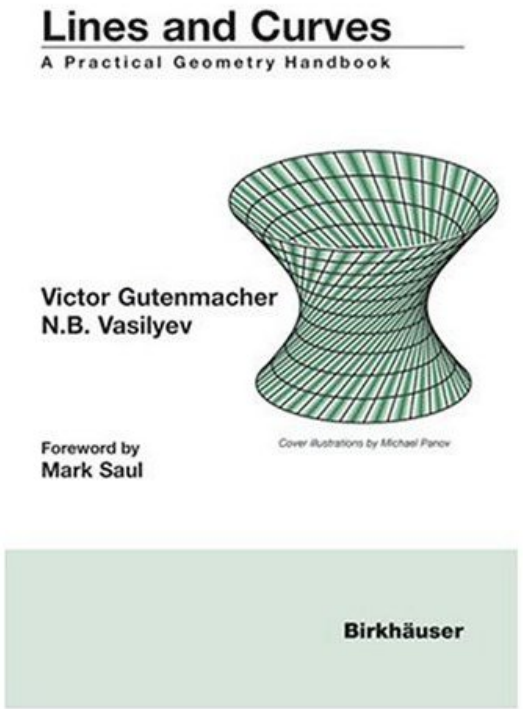
Choice of problems

Taken from V. Gutenmacher and N.B. Vasilyev. *Lines and curves: a practical geometry handbook*. Birkhauser, 2004.



Reasons

- Geometry
- Locus problems, *kinematics*, (machine motion)
- Modelling aspects
- Little prior knowledge
- Often different solution approaches

Example: the cat on the ladder

0.1 A ladder standing on a smooth floor against a wall slides down to the floor. Along what curve does a cat sitting in the middle of the ladder move?

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CS's reflections, 4 years

Surprising consistency and stability.

Each year we have ended up 40 ± 2 problems from the same place. (35 pages out of 148)

- **Week 1** Anticipation.
- **Week 2** Excitement and enthusiasm.
- **Week 3** Frustration.
- **Week 4-5** Despondency, Doldrums and Despair.
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Quantitative Study

We want to determine whether 1Y has any effect on students' performances in other modules in the School of Mathematics.

6494 module results from 947 students over nine academic years were used for quantitative analysis.

- We could use independent t-tests to compare the mean scores of 1Y and non-1Y students.
- 1Y students are a self-selecting group

		t-test for Equality of Means						
							95% Confidence Interval	
	Equal Variances	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
1Aa Mark	Assumed	-4.59	826	0.0000	-11.96	2.60	-17.08	-6.85
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Linear regression allows us to remove the effect of 1Y students being better to begin with.

- We predict first year results using 1Aa class test mark and 1Y participation
- We predict second year results using first year mean and 1Y participation
- The models have the equation

$$\text{Module mark} = \beta_0 + \beta_1 CT + \beta_2 Y.$$

- Third year results were inconclusive - too little data to for significant results

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Quantitative Results

First year regressions

Module	Subject Areas	1Y Coeff.	F-Test Sig.
1Aa	Calculus, Geometry, Matrices	4.47 (1.81)	0.014
1Ab	Calculus and Algebra	7.00 (2.70)	0.010
1B	Number Theory, Sequences & Series	7.37 (2.26)	0.001
1C	Mechanics & Computational Math(s)	-0.04 (2.40)	0.987
1D	Discrete Math(s) and Statistics	3.60 (2.36)	0.127

Second year regressions

Module	Subject Areas	1Y Coeff.	F-Test Sig.
203	Polynomials, Rings & Metric Spaces	7.62 (3.64)	0.038
2B	Real and Complex Variable Theory	4.50 (2.48)	0.071
2C	Linear Algebra & Programming	4.04 (2.53)	0.110

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[1] A (hopefully) representative sample bound by the strictures of biased observers

What is proof?

Results: end of course questionnaires in 2008 and 2011

Typical answers:

> *a logical step by step argument that, with no unnecessary steps, that shows without a doubt that the statement is true.*

> *A mathematical proof is a deductive process where, starting from already proven theorems and other facts, we can deduce through a series of undisputable steps a required result.*

What is proof?

Results: end of course questionnaires in 2008 and 2011

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Has your concepts of proof changed?

Yep! At first my idea was of a proof was writing long chunks of work and simplity hoping the correct proof was in there. As I gained more experience I found a good proof is consise and to the point. Rather then writing pages and pages for a proof with unnessary info I learnt to shorten my work down to say a page with just the nessary info.

that it is not necessarily a long winded argument and the most satisfying proof is a short one.

Yes, I use to feel that the complicated long proofs always were the 'best' i can now appreciate that this is far from true.

Did anything in the course surprise you?

The amount of work and how hard it was.

It surprised me how much I learnt without really any direct teaching. I was expecting to be taught topics and then be set problems based on those topics but the self-taught approach was much more effective that I would have anticipated.

Not sure if it counts as an event, but just the fact that i actually really enjoyed geometry. Before the course i would have said I didn't like it at all, but now i realise this is not ture, and really wish I could do geometry next year.

Thales theorem may as well be the meaning of life at this rate.

Not all students engaged...

Overall i think that it is an extremly interesting course and in a way wish i had turned up to more lectures and given it alot more time. When signing up i had no idea how much hardwork it would be and deffinitly sturggled to keep up with the pace of the course. It is obviopusly my fault that i failed and will have to retake it as i failed to turn up to most of the lectures but think that its a tiny bit unfair that people gained 20 credits doing the other maths course which could have easily passed with out paying much attention

[. . .]

I think the main probelm is that a momd at birmingham is sort of seen as abit of a joke and easy credits but y is deffinitly not that.

[. . .]

Anyway sorry if that seems a tiny bit direct and rude as i dont want to come arcross that way as i do think it was a very well run course, just probably one i shouldn't have done.

Thank you anyway

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Conclusion

- Importance of staff ownership.
- Large lectures in years 1 & 2 mean structural support required.
- Evidence of efficacy
  - quantitative &
  - qualitative, (delayed post-testing, social, affective, etc.)
- It can be difficult to convince colleagues.
  “It is a luxury we can’t afford"
  We can’t afford to omit it!
- *Some* students fail to engage.
  They are trapped .... stakes are very high.
- The future. . .
  - All MSci (four year master) students will be required to take IBL starting this autumn.
  - University of Leicester has introduced a "Moore Method" course in its first year, but individual staff have a lot of say in the structure and it does not follow a single, strict pedagogy.

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