MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

MatRIC Mathematical Modelling Colloquium
Kristiansand, Norway
August 9-11, 2016

MATHEMATICS LECTURERS' VIEWS ON THE TEACHING OF MATHEMATICAL MODELLING

Olov Viirman

Yuriy Rogovchenko

UNIVERSITY OF AGDER

Paul Hernandez-Martinez

Stephanie Treffert-Thomas

Loughborough University

- Students find mathematical modelling difficult (e.g. Soon, Tirtasanjaya & McInnes, 2011).
- There are many definitions of MM in the mathematics education literature (e.g. Blum, Galbraith, Henn & Niss, 2007; Frejd, 2011).
- There is vast amount of research into all aspects of modelling (e.g. Blum & Niss, 1991, for a comprehensive review including a classification of different approaches to teaching and reasons for including applications and MM in instruction).

- If modelling is an important and necessary skill to acquire then teaching modelling is also important and necessary.
- Hence we believe it is timely to analyse the lecturers' views on mathematical modelling in order to develop effective programs which can support teachers/lecturers interested in adopting a mathematical modelling approach in their teaching.

Rather informally, a (mathematical) model is …

"a simplified version of a real-world system" (Levy, 2015)

"a simplified, idealized and approximate representation of the structure, mechanism and behavior of a real-world system" (Domotor, 2012)

"a simpler realization or idealization of some more complex reality" (Lucas, 1999)

"a translation of a real-world problem into mathematics notation by forming a mathematical problem corresponding to the real-world problem" (Shahin, 2014)

"a representation in mathematical terms of the behavior of real devices and objects" (Dym, 2004)

"a mathematical construct designed to study a particular real-world system or phenomenon" (Giordano, 2003)

Formal definitions of a (mathematical) model

"To an observer B, an object A* is a model of an object A to the extent that B can use A* to answer questions that interest him about A." (Minsky, 1965)

"A mathematical model is a triplet (S,Q,M) where S is a system (an object or a collection of objects whose properties we want to study), Q is a question relating to S, and M is a set of mathematical statements M which can be used to answer Q." (Velten, 2009)

"A mathematical model consists of the extra-mathematical domain, D, of interest, some mathematical domain M, and a mapping from the extra-mathematical to the mathematical domain." (Niss, 2007)

Mathematical modelling is …

"a discipline that attempts to describe real-world phenomena in mathematical terms and then solves them" (Upadhyay & Iyengar, 2014)

"the use of mathematics as a tool to make predictions of natural phenomena" (Taubes, 2008)

"the application of mathematics to real-world problems" (Albright, 2010)

"the application of methods to analyze complex, real-world problems in order to make predictions about what might happen with various actions" (Shiflet & Shiflet, 2014)

"a procedure in which a system of mathematical equations is developed to simulate the behavior of a physical system" (Kelly, 2008)

Difficulties in (teaching of) modelling

"Mathematical modelling is a subject without boundaries in every conceivable sense." (Illner, McCollum, van Roode, 2005)

"We define the process of model building as an unending one - one with rewards typically proportional to the effort extended." (Hannon, 1997)

"Our model will neither be complete nor will it be perfect." (Müller & Müller, 2003)

"The test of a good model is that it works, that it does the job for which it was intended." (Isaac, 2013)

G. Kaiser and B. Sriraman, A global survey of international perspectives on modelling in mathematics education. ZDM, 38 (2006), 302–310.

REALISTIC	Pragmatic-utilitarian goals: solving real-world problems, promoting modelling competences
EPISTEMOLOGICAL	Theory-oriented goals: development of theory
CONTEXTUAL	Subject-related and psychological goals: model *for* as opposed to model *of*
EDUCATIONAL **Didactical** **Conceptual**	Pedagogical goals: Structuring of learning processes Concept introduction and development
SOCIO-CRITICAL	Pedagogical goals: such as critical understanding of the world; emancipation
+ ENJOYMENT	Intrinsic goals: satisfaction and appreciation of the beauty of mathematics

- 1) What are lecturers' views of the aims of mathematical modelling in professional practice and in teaching?
- 2) To what extent and how is mathematical modelling used in teaching?
- 3) What supports or hinders the use of mathematical modelling in teaching?

Questionnaire (example questions)

The aim of practicing mathematical modelling (in your professional capacity) is

to describe, explain and/or predict reality.	
to advance mathematical theory.	
to foster creativity.	

The aim of teaching modelling is for students ….

to become more critically aware as citizens.	
to gain conceptual understandings of mathematics.	
to learn to apply models and modelling to different situations.	

Questionnaire (example questions)

If you use(d) models and/or modelling in your teaching, which statement best represents how you use(d) it?

Mathematical modelling is taught as a separate course.	
Small mathematical pure units are followed by applications where modelling is used.	
Mathematical models are used as illustration of theory.	
Mathematical modelling is used as motivation for introducing new theory.	
None of the above. (Can you provide more details below?)	

We asked

(a) what would be the 'best way' to use MM in teaching and

(b) when lecturers would be ready to adopt that way.

We also asked those who did not use MM in their teaching to briefly explain why not.

- 498 surveys sent out to Norwegian university mathematics lecturers.
- Response rate: 24%
- Demographic results (age, gender, experience, research active).
  - PhD specialization: 119 respondents were fairly equally divided between pure mathematics (31%),
  - applied mathematics (31%) and
  - other subjects, including physics, statistics and mathematics education (27% in total).

Views of MM

3 realist statements chosen	**41**	**45%**
2 realist statements chosen	32	35%
3 epistemological statements chosen	0	0%
2 epistemological statements chosen	8	9%
3 enjoyment statements	0	0%
2 enjoyment statements	3	3%
Mixed (one chosen from each category)	7	8%
Total	91	100%

Views of MM (first choice)

realist	77	85%
epistemological	9	10%
enjoyment	5	5%
None of the above	0	0%
Total	91	100%

Aims of teaching of MM

2 realist	**28**	**35%**	
2 epistemological	3	4%	
2 enjoyment	3	4%	**47%**
2 socio-critical	2	2%	
2 educational	1	1%	
2 contextual	1	1%	
No two from same category	43	53%	53%
Total	81	100%	100%

Aims of teaching of MM (first choice)

realist	41	50%
contextual	16	20%
educational	8	10%
epistemological	7	9%
socio-critical	5	6%
enjoyment	4	5%
Total	81	100%

How MM was used in teaching		
74% used MM	To illustrate theory	30% (25)
	To motivate new theory	16% (13)
	Separate course	16% (13)
	Small pure units of maths + applic.	9% (7)
	Own description	2% (2)
	None of the above	1% (1)
26% did not	------	26% (21)
Total	Total	100% (82)

Conditions that support or 'hinder' teaching MM

Factor	Supports MM in teaching	Does not support MM in teaching
Nature of mathematics: Comments referred to the nature of mathematics or the content of modules.	MM is integral to teaching mathematics, and hence relevant in teaching both pure and applied mathematics.	Modelling is not relevant for pure mathematics.
Institutional issues: Comments related to teaching practices and programme structure.	When MM is an element or small part of a course.	Lack of time or opportunity, when MM is taught as a separate course.
Teaching skills: Comments related to teaching.	Mathematicians have the necessary skills (as dominant discourse is realistic/applied).	Lack of experience, lack of skills in using and/or teaching modelling.
Student profile: Reference was made to students.	Students are interested and able.	Students are academically weak.

Summary of conditions that support or 'hinder' MM in teaching

Results

Category	Examples when most likely MM is used	#
Mathematics specific. Dependent on the mathematical content of a course	modelling "to illustrate theory", "when teaching dynamical systems", "to model ecology and evolution or to show an application".	30 (52%)
Dependent on institutional level decisions and institutional practice	"Whenever possible", "when it fitted naturally", "when time allowed", "when [having] more freedom or control over course or curriculum".	16 (28%)
Most common response was "Always" implying that modelling is integral to teaching	"Always", "..in most courses".	8 (14%)
Student profile. Dependent on students' interest or ability	"enough students …are interested", dependent on "students' ability".	4 (7%)
Total number of responses		58

Implications

- The implications from this study – coming from a relatively small and opinioned sample – for university teaching are:

- (a) MM should be explicitly documented in the curriculum.

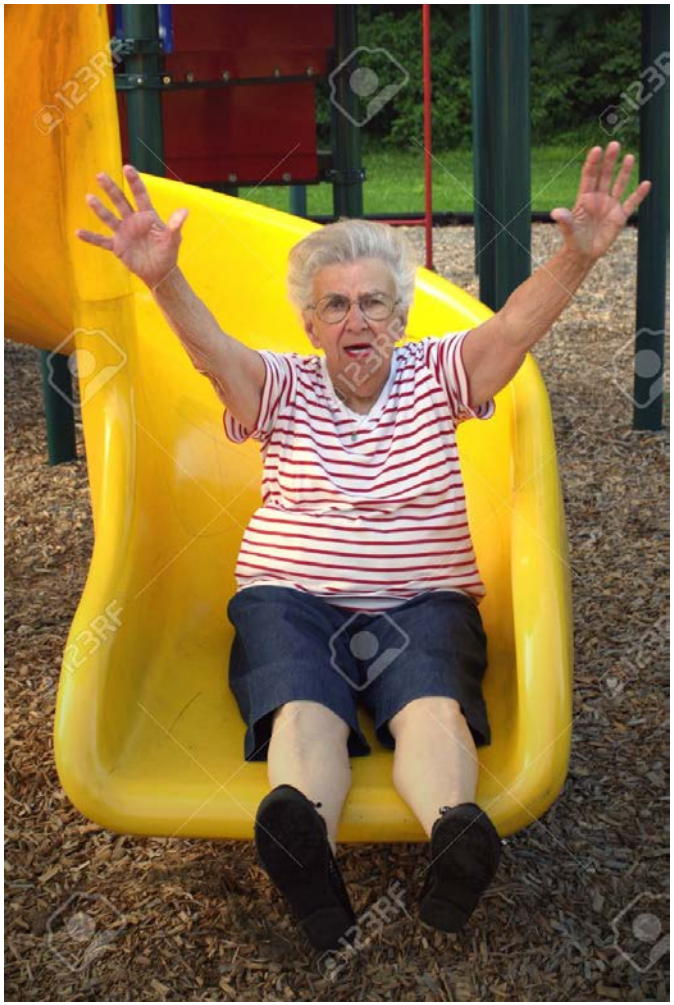
- (b) Mathematics education researchers and lecturers should collaborate closer so that the latter become aware of other aims of using MM in teaching (as detailed in Kaiser and Sriraman, 2006, for example) that could be advantageous for learners and create diversity in the learning of mathematics.

- it is less clear to what extent institutional support in terms of course structuring could positively affect the use of MM in teaching.

References

- Blum, W., Galbraith, P.L., Henn, H. & Niss, M. (Eds.). (2007). *Modelling and applications in mathematics education. The 14th ICMI study*. New York: Springer.
- Blum, W. & Niss, M. (1991) Applied Mathematical Problem Solving, Modelling, Applications, and Links to Other Subjects: State, Trends and Issues in Mathematics Instruction. *Educational Studies in Mathematics*, 22 (1), 37-68.
- Frejd, P. (2011). *Mathematical modelling in upper secondary school in Sweden: an exploratory study* (Licentiate thesis). Linköping University.
- Kaiser, G., & Sriraman, B. (2006). A global survey of international perspectives on modelling in mathematics education. *ZDM*, 38(3), 302 – 310.
- Soon, W., Tirtasanjaya, L. & McInnes, B. (2011). Understanding the difficulties faced by engineering undergraduates in learning mathematical modelling. *International Journal of Mathematical Education in Science and Technology,* 42(8), 1021 – 1039.

This is the last slide ☺



Thank you very much for listening!