MatRIC Modelling Colloquium August 2016: Abstracts

Modelling for Teaching and Learning of Differential Equations

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Presentation of the course ’Modelling in and for mathematical teaching and learning’ which is a 15 ECTS compulsory course in our maters’ programme in mathematics education at University of Bergen. The course encompasses two group projects: One project aiming at the students’ learning about differential equations modelling and one project where the students prepare teaching materials for their pupils’ modelling. The course runs over 4x3 full days and 25% of the time and focus is on differential equations (Laplace transformation, use of ICT tools, qualitative vs quantitative perspectives etc.).

Teaching Multidisciplinary Groups of Graduate Students Advanced Mathematical Modelling

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With the increasing power of computational techniques, computer modelling became a tool that university level students use almost daily.
This tool is essential in biology, physics, cybernetics, engineering, and economy, almost as the calculator was for the engineer 20 years ago.
Students from various disciplines, however, do not receive uniform and standardized education in modelling. They are trained to achieve similar skills but often by conflicting methods.
Serious problems emerge when these students take multidisciplinary courses such as mathematical biology, environmental ecology, industrial economy, bioengineering, and medical cybernetics, subjects that are becoming increasingly popular. These problems express themselves in frustrations of students, a rapid decline in motivation and large drop-outs. Moreover, large heterogeneous groups of students show complete lack of collaboration, an alarming situation in subjects that should strongly link knowledge from different fields. This calls for solutions that stem from decision makers of higher ranks in universities, and cross-disciplinary committees that should devise uniform learning procedures for student of all disciplines, in order to prevent future conflicts.

The PISA Scoring Guidelines and Their Prescriptions for Interpreting a Problem Situation

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Abstract: The large scale PISA project comprises an assessment for mathematics with problems set in real life. According to PISA’s aims, students are expected to integrate extra-mathematical knowledge into their problem solving. We studied to what extent the scoring guidelines are open to evaluate students’ use of extra-mathematical knowledge. As theoretical frame, we used Bourdieu’s concept of ‘field’. The study was carried out with twelve grade 9 students working in pairs on the ‘Pizzas’ problem. To solve it, students have to formulate a mathematical model that captures the term ‘value for money’. The results show that the PISA scoring guideline prescribes certain fields (economic, school mathematics), while the ‘Pizzas’ problem triggers

students to think of participating in social, gastronomic, micro-financial, or health fields. They thoughtfully formulate mathematical models that fit these fields, but that will not receive credits according to the PISA guidelines. We recommend that PISA's scoring guidelines can be more open to different interpretations instead of prescribing only one. Opening to a variety of interpretations does align well with PISA's aims.

Modelling in an Integrated Physics and Mathematics Course

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The curricular design of the course focuses on the construction of physics and mathematics models in which students work collaboratively during the semester. Pedagogical approaches and instructional design principles combine to bridge the gap between physics and mathematics. Models and modelling perspective provides the framework for the design of activities that motivate students to develop the mathematics needed to make sense of meaningful situations, whereas modelling instruction provides the structure of collaboration and sharing learning through argumentation and negotiations of meanings. One of the key elements of the integrated course is that students actively engage in the cycle of conjecturing, testing and revising their ideas. This cycle allows them to make strong predictions and construct robust models. The classroom setting fosters students learning through collaboration. The key element of the classroom is the round tables that sit three groups of three students, that is, nine students per table. A final project requires students to connect, in a congruent way, the main ideas learned and to communicate them orally and in writing. Students noted that the course reduced boundaries between physics and mathematics, helping them to better understand the application and need for the mathematics content.

Differential Equations and Mathematical Biology: Anatomy of Some Applications

Jorge Duarte

ISEL-Engineering Superior Institute of Lisbon, Portugal

Mathematics has long played a decisive role in our understanding of physics, chemistry and other physical sciences. However, the application of mathematical modelling in the life sciences is relatively recent. The complexity of biological sciences makes the close interaction between scientists of different disciplines crucial for realism and significance of the obtained theoretical results. Now, questions about epidemiology, virology, cell movement, cell signaling, complex ecosystems, among others, are being tackled and analysed using mathematical and computational methods. While mathematical biology is one of the fastest growing research areas in applied mathematics, it is rarely offered in undergraduate education.

A special domain of mathematics, regarding its conceptual richness and applicability, is the theory of differential equations. With a friendly and clear mathematical treatment, this talk provides the anatomy of some applications of the quantitative and qualitative theory of differential equations to biological rhythms. Given the illustration of some eye-catching and noteworthy features of the interdisciplinary work in mathematics applied to biology, this presentation is likely to appeal to a wide audience, fascinated by the wonders of the nonlinear world.

Integrating Mathematics and Modelling into Life Science Programs

André Heck

University of Amsterdam, Netherlands

Teaching and learning mathematics and modelling in life science is challenging for both teachers and students. Teachers must deal with students who have in general different backgrounds in mathematics and sometimes have developed an aversion to mathematics, even though they choose a study in exact sciences. Teachers must find a balance between teaching mathematical methods, applications, and modelling in limited time. Students are challenged because they might struggle with mathematics, do not see its value, have problems with the amount of knowledge and skills, and have unrealistic expectations on how it will be used in their fields and what is needed for this.

In this talk I present how teachers at the University of Amsterdam try to face the many challenges in the first study year of life sciences with ICT supported courses, what kind of applications of mathematics are used, and how modelling is integrated herein. This will be done by presenting concrete instructional materials from the first study year and from the second study year, when modelling becomes a larger part of the courses. Examples are taken from biology, biomedical sciences, and neuroscience. Some of the examples can also be used at an advanced mathematics secondary school level.

Ownership and Alienation in Mathematical Modelling Group Work Activity

Paul Hernandez-Martinez

Loughborough University, England

In this talk I will present the work of two groups of undergraduate engineering students solving a coursework modelling task throughout a period of four weeks. In their group conversations and their struggles in trying to make sense of the problem, it is clear that there is a mixture of emotions that at times hinders and at others facilitates their understanding and progress. I will explain their collaborative work through the concepts of alienation (e.g. "This has nothing to do with me") and ownership (e.g. "I'm proud of our solution"). I will finish with a more general discussion about alienating practices in mathematics and if or how can modelling encourage students' sense of responsibility for their own learning.

Engineering Students' Communication and Visualization During Modelling Using a Simulation Tool

Ninni Marie Hogstad

University of Agder, Norway

In this presentation I describe a case study of group work by three engineering students. I studied their communications and visualizations while modelling the motion of two cars. The students worked with a digital tool, in which one sees two cars run along a straight line from a starting line to a finish line. To make the cars move, students needed to insert velocity functions into the tool. The tasks were inter-disciplinary, requiring students to use mathematical concepts such as functions, integrals, parameters and graphs, and physical concepts such as velocity, distance and time. The tasks asked the students to make simulations that fulfilled different requirements, for example have the cars start and finish simultaneously but run differently in between. I describe how students suggested and verified five different models, a variety of visualizations which were used to find these models and how they used the tool. The tool was mostly used for verification of these mathematical models for the cars' motions.

Visualization and Simulation Tool as an Extra Resource in Mathematical Modelling

Per Henrik Hogstad

University of Agder, Norway

SimReal, a visualization and simulation tool being developed at UiA, has for some years been tested and used among engineering students and teacher students at UiA. In this presentation I will show some simple and a bit more advanced examples where visualization and simulation can be of additional help in the modeling process. Visualization and simulation can be useful both in clarifying the result of the mathematical model, and of some help also in front and during the modelling process.

Mathematical Modelling and Mathematical Competencies: The Case of Biology Students

Ioannis Liakos

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My study involves a number of interventions in a standard freshmen mathematics course for biology students. The intervention aims at introducing mathematical modelling tasks in order to engage students more actively into learning mathematics through modelling tasks that are biologically "coloured". My focus will be on the individual progression (if there is any) of students' mathematical competencies during the sequence of modelling sessions. There is an increasing amount of literature which provides documentation for the learning benefits associated with engaging students in mathematical modelling. There is a 'red thread' among many researchers who, through the description of mathematical modelling processes found an analytical tool to for identifying competencies involved in modelling (Kaiser et al., 2006). Students engaged in modeling may develop a deep understanding of the content and an ability to solve novel problems (e.g. Wynne et al. 2001, Lehrer & Schauble 2005). Other studies (Schwarz & White 2005; Windschitl et al. 2008) have shown that modeling curricula can bring students into alignment with the epistemic aims of science and help them develop more sophisticated ideas about the scientific enterprise as a whole. Sriraman et al. (2009) blended the notion of interdisciplinarity with modelling highlighting the necessity for creativity and giftedness across disciplines. It comes as no surprise that "*both the National Research Council (NRC) and the National Science Foundation (NSF) in the U.S [are] increasingly funding universities to initiate inter-disciplinary doctoral programs between mathematics and the other sciences with the goal of producing design scientists adept at using mathematical modeling in interdisciplinary fields*" (Sriraman & Lesh, 2006, p.247)
Taking the above into consideration I make the two assumptions that (1) modelling has the potential to sharpen students' mathematical competencies and also (2) supports meaningful reform efforts in scientific education. My research is focused, though, on the first assumption: can mathematical modelling assist a student to develop mathematical competencies?

The Inquiry Oriented Differential Equations Project: Addressing Challenges Facing Undergraduate Mathematics Education

Chris Rasmussen

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Undergraduate mathematics education today faces a number of new challenges and difficulties. One way to address these challenges is to build on promising theoretical advances and instructional approaches, even those not originally developed with undergraduate mathematics in mind. The Inquiry Oriented Differential

Equations Project (IODE) is one such effort, which can serve as model for other undergraduate course innovations. In this presentation I describe central characteristics of the IODE approach, report on results of a comparison study, and detail how modeling tasks resulted in two surprising results: student reinvention of an analytic approach for solving linear homogeneous systems of differential equations and the reinvention of a bifurcation diagram. I use the bifurcation diagram reinvention example to develop the notion of brokering, which speaks to the unique role of the professor in student reinvention of significant mathematical ideas. The notion of brokering, which generalizes beyond differential equations, highlights how teaching and learning mathematics is a cultural practice, one that is mediated by and coordinated with the broader mathematics community, the local classroom community, and the small groups that comprise the classroom community.

Mathematics Lecturers' Views on the Teaching of Mathematical Modelling

Stephanie Treffert-Thomas[a], Olov Viirman[b],

Paul Hernandez-Martinez[a] and *Yuriy Rogovchenko[b]*

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We report on the views and use of mathematical modelling (MM) in university mathematics courses in Norway from the perspective of lecturers. Our analysis includes a characterisation of MM views based on the modelling perspectives developed by Kaiser and Sriraman (2006). Through an online survey we aimed to identify the main perspectives held in higher education by mathematics lecturers and the underlying rationale for integrating (or not) MM in university courses. The results indicated that most respondents displayed a realistic perspective on MM when it came to their professional practice. There was a more varied response when it came to their views on MM in teaching. Regarding conditions influencing the use or non-use of MM in teaching, these mainly concerned the mathematical content and the institutional practices.

Modelling: Fun, Effort and Use

Peter Uylings

University of Amsterdam,Netherlands

"*All models are wrong, but some models are useful." (George E.P. Box, 1919)*

Modelling is increasingly topical in science education, like it has always been in science itself. Modelling is the way a scientist observes and thinks about nature.

Recent innovations in the physics curriculum of the upper secondary pre-university schools, focus on modelling both qualitatively as an important tool of approaching and solving problems, and quantitatively as a means of dealing with more authentic but more complex dynamic problems using a computer.

Virtually every problem of the yearly national pre-university exam has been substantiated by models. This talk will focus on modelling as an enduring learning-teaching trajectory that bridges the gap between upper secondary physics and the bachelor physics curriculum. A case in point is quantum mechanics that has recently been introduced in higher secondary education, demanding bachelor quantum lecturers to use a context-concept approach and the use of models to fit their student's expertise.

Also, physics students have to study models extensively in their training to become a physics teacher.

A range of concrete examples of such models and corresponding animations will be demonstrated.

The Mathematical Discourse of Biology Students Working with Mathematical Modelling Activities – a Commognitive Perspective

Olov Viirman

University of Agder, Norway

This presentation concerns a collaborative project between two of the Norwegian centres of excellence in higher education (MatRIC and bioCEED) in which biology-related mathematical modelling tasks are introduced to biology students as a means of motivating them to engage more deeply in mathematical studies. The first phase of an ongoing developmental research project, involving four meetings with 11 first-semester students, is described. The mathematical discourse of the students as they engage in the mathematical modelling activities is analyzed using the commognitive framework of Sfard. Initial findings of the analysis include, for instance, indications of a connection between the degree of student agency and the level of mathematical engagement with the tasks, where a low degree of agency is associated with ritualized routine use. Some implications for the next phase of the project, as well as for research on teaching mathematics to non-mathematics specialists more generally, are presented.

"Why Do I Have to Learn This?": The Concept of 'RELEVANCE' in Mathematical Modelling Education

Paul Hernandez-Martinez[a] and *Pauline Vos*[b]

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In this presentation we explore the concept of 'relevance' and its role in students' motivation to engage in mathematical modelling activities. Niss (1994) expressed the 'relevance paradox' as the tension between the relevance of mathematics in society and the irrelevance as perceived by many students.
Based on Cultural-Historical Activity Theory, we define 'relevance' as the property of an activity which is judged by a person or persons to have some value connected to the motive or object of the activity. We illustrate this definition with two case studies in higher mathematics education. The case studies illustrate that 'relevance' can be mediated by a student's identity or by authentic aspects of the activity. It remains important to note, that an activity may be judged as 'interesting' but not as relevant, or vice versa.