ICTMA Newsletter

The International Community of Teachers of Mathematical Modelling and Applications.
www.ictma.net

The Community, through its membership, research and other activities, is recognised as "The International Study Group for Mathematical Modelling and Applications (ICTMA)" by its affiliation to the International Commission on Mathematical Instruction (ICMI).

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Please send future contributions to the editor by email <g.stillman@unimelb.edu.au>. The next Newsletter will be published in August, 2009. We are interested in your contributions to any of the current sections.

1. International Executive Committee

The current ICTMA Executive is as follows:

President
    Prof Gabriele Kaiser (Germany)
Past Conference Organisers
    Prof Chris Haines (UK) – Secretary
    Prof Richard Lesh (USA)
Elected Members
    Toshikazu Ikeda (Japan) – Registrar
    Thomas Lingefjärd (Sweden)
    Gloria Stillman (Australia) – Newsletter Editor
Co-opted Members
    Jonei Barbosa (Brazil)
    Katja Maaß (Germany)
    Bhadra Tuladhar (Nepal)
    Jinxing Xie (China) – Webmaster & List Serve Moderator

3. Forthcoming ICTMA Conferences

The ICTMA group has held biennial meetings since 1983. This conference series provides a forum for discussing all aspects of teaching applications and mathematical modelling in all areas and at all levels of mathematics education – from primary to secondary schools, at colleges and universities. The next two ICTMA Biennial conferences will be ICTMA 14 in Hamburg in 2009 and ICTMA 15 in Melbourne in 2011. ICTMA 14 is close approaching.

14TH INTERNATIONAL CONFERENCE ON THE TEACHING OF MATHEMATICAL MODELLING AND APPLICATIONS (ICTMA14)

The 14th ICTMA Conference - ICTMA14 - will be held at the University of Hamburg and organised by the Faculty of Education, Working group on didactics of mathematics. It will be chaired by Professor Gabriele Kaiser with Dr Rita Borromeo Ferri as co-chair. The conference is scheduled from

Monday, 27th July to Friday, 31st July 2009
Paper Abstract Submissions due 20th February 2009

Academic programme:

A variety of activities is planned, including plenary lectures and paper presentations. Prof Werner Blum and Prof Hemut Neunzert from Germany, Dr Gloria Stillman from Australia, Prof Chris Haines from UK and Prof Richard Lesh and Prof Helen Doerr from USA have been invited to give plenary addresses. In addition there will be a Panel Discussion involving invited speakers from several parts of the world to discuss the topic: *Modelling Perspective from Around the World— State-of-the-Art*.

The following issues will be tackled:

(i) Pedagogical issues, such as the understanding of modelling, promotion of modelling competencies, cognitive aspects;

(ii) Assessment of modelling activities in school and universities;

(iii) Connections to industrial or commercial practice, mathematics at the workplace;

(iv) Influences of technology;

(v) Cross-cultural aspects and international studies.

Conference venue:

The conference will take place in the building of the Faculty of Education at the university's Campus Von-Melle-Park. The Campus is situated near Lake Alster in the very heart of Hamburg.

Conference fee:

The conference fee will is 350 € if paid by 15 April, 2009, or 400 € thereafter with a possible reduction for young researchers and will include various events, such as a guided city excursion, conference dinner, snacks and lunch and a hardcopy of the conference proceedings.

Social programme and accommodation:

There will be a strong social programme for participants, and a complementary programme for accompanying persons. Participants can also arrange pre- and post-conference tours to Germany's new capital Berlin.

A great variety of hotels and cheaper accommodation are in walking distance.

The City:

The "Freie und Hansestadt Hamburg", Germany`s second biggest metropolis (1.8 million inhabitants) is a bustling, cosmopolitan port city. Hamburg is situated between the North Sea and the Baltic Sea and easily reachable by its internationally connected airport. The Lake Alster together with the Elbe river, numerous canals and parks adjoining them, have made Hamburg well-known as a "green" metropolis at the water's edge.

The University:

The University of Hamburg is a state university of the "Freie und Hansestadt Hamburg". Hamburg's view of itself as "gateway to the world" is reflected by the university's diversity of scientific areas and educational possibilities and thus it presents itself as "gateway to the world of knowledge". 38,700 students are inscribed at the University of Hamburg and 851 professors are engaged in teaching and research.

Transport

Hamburg is easily reachable by its internationally connected airport.

For further information, please email to the conference secretary Karen Stadtlander:

stadtlander@erzwiss.uni-hamburg.de

or see the conference website at: http://www.erzwiss.uni-hamburg.de/ictma/ or www.ictma14.de/

3. Brief News Items

3.1 Short Preliminary Notice

The Mathematics Education into the 21st Century Project & The University of Applied Sciences (FH), Dresden (Germany) have just finalised the Second Announcement and Call for Papers of their 10th (Anniversary!) International Conference: *"Models in Developing Mathematics Education"* , Sep 11–17, 2009 in Dresden, Saxony, Germanyin full cooperation with the Saxony Ministry of Education. International Organisers: Dr. Alan Rogerson, Coordinator of the Mathematics in Society Project (Poland) & Prof. Fayez Mina, Faculty of Education, Ain Shams University (Egypt). Chair of the Local Organising Committee: Prof. Dr. Ludwig Paditz, Dresden University of Applied Sciences. For ALL further conference details and updates please email alan@rogerson.pol.pl <mailto:arogerson@inetia.pl><about:blank> and see http://www.informatik.htw-dresden.de/~paditz/SecondAnnouncementDresden2009.doc<http://math.unipa.it/%7Egrim/convegni.htm>

Alan Rogerson

3.2 GeoGebra

The computer program GeoGebra is spreading rapidly around the world. It is free, it is professional, and it combines Algebra (even matrices), Geometry, Statistics and Curve fitting just to mention some features in next release in February 2009. See www.geogebra.org.

Thomas Lingefjärd

3.3 New Journal on Modelling

The new journal featuring mathematical modeling that was expected to be launched in 2008 in Brazil will begin publication in 2009. It will be published through the Reference Center for Mathematical Modelling in Teachng (CREMM). The journal will be called the *Journal of Modelling and Mathematical Applications*. There will be 3 editions a year in March, July and November. The first editions will be on-line. Papers can be up to 35 pages; space 1.5, Times New Roman; A4. Contributions can be: original research papers, review articles, short communications, or book reviews. Papers will be refereed and the journal has an international editorial board. Submissions can be sent by e-mail to: cremm@furb.br or to: salett@furb.br The journal website is proxy.furb.br/ojs/index.php/journal

Maria Salett Biembengut

3.4 Announcement of New Journal and Call for Papers

RIPEM - *International Journal for Research in Mathematics Education / RIPEM -Revista Internacional de Pesquisa em Educação Matemática -* is a new international journal on mathematics education. The goal of RIPEM is to provide a new forum to publish and access high-quality research reports. The papers are expected to report findings from empirical research and literature-based scholarly articles that advance theories and scholarship of Mathematics Education. The journal has an acknowledged Editorial Board, ensuring high academic standards and broad international coverage.RIPEM is published by the Brazilian Society for Mathematics Education, and it will be published online and free of charge. Both emerging and established researchers are invited to submit manuscripts to inaugural and future issues. All manuscripts should only be submitted in English. They will be refereed anonymously by at least two referees. Manuscripts presented in previous conferences could be extended and submitted, as long as the submission provides a clear contribution beyond the conference paper, and the overlap is carefully described in the RIPEM submission.The website of the journal and its web-based submission system is already open. In order to learn more about the editorial policy and submission guidelines, all researchers are invited to visit this address: http://www.sbem.com.br/ojs/index.php/ripem/index Although papers are welcome at any time, the deadline to submit a manuscript for consideration in the inaugural issue is 5th February 2009. All efforts will be made to ensure that the refereeing and publication processes will be fast in order to launch the inaugural issue.

Jonei Barbosa

4. Reports from Regional Areas

4.1 AB Paterson College Mathematical Modelling Challenge in Australia

November 2008 saw the fifth annual Mathematical Modeling Challenge for primary and secondary school students held on the Gold Coast, Queensland. The Challenge has been held annually at Griffith University, Gold Coast Campus. It was begun in 2004 by Trevor Redmond, AB Paterson College and has been sponsored annually by the College, Griffith University, Texas Instruments and various other orgainisations and businesses. Students in Years 4-11 come from all over south east Queensland to participate in the two day Challenge. In the senior part of the Challenge students work in groups on a modelling problem of their own choice such as the effects of caffine in beverages such as Red Bull or Starbucks coffee or the effects of fluoridation of water supplies on deciduous teeth whereas in other age groups students work on a set task such as "Which country did best in the Beijing Olympics?" At the end of the two day Challenge each group has to present a poster of their investigation and solution. Academics, some of whom are ICTMA members, from several universities in Queensland and Victoria and teachers from AB Paterson College work as mentors facilitating the groups for the two days.

5. Project Reports

5.1 DQME II Project

The Medicine project

The 2008 endeavor in the DQME II project was that the Danish and Swedish members of the DQME II research group decided to use a mathematical modeling problem from medicine (see Appendix 1 & 2 in Lingefjard, 2009) as their next mutual project. It is a fact that many students seem to appreciate modeling problems from the area of medicine as more real and more interesting than others (Lingefjärd, 2006, p. 111). Also the Hungarian and Romanian colleagues in the DQME II project agreed to use the same problem in their schools. One main concern was what the gymnasium (upper secondary) teachers in the respective country would think about the problem? Would they approve the level of mathematical thinking? Would they approve the directions of inquiry? Mutual teaching experiments across cultural and national borders require a lot of work and concern some very delicate issues. It is a fact that no one in the research group knows much about the actual teaching that takes place in Danish, Hungarian, Romanian or Swedish classrooms as existing apart from their own countries. The research group agreed about the intention to film the experiments in the classrooms. Would that become an obstacle or an opportunity to run the project even better? What about the actual teaching and learning that will take place? In what way will that effect the facilitation of mathematical thinking in the classrooms?

Norwegian and Swedish mathematics education researchers has created a subset of Maxima for the upper secondary school, thereby allowing students in age 15-18 to have a advanced tool in which they can do CAS activities but also modeling. This special subset is translated into English, Norwegian and Swedish. http://www.moglestu.vgs.no/maxima/maxima-5.14.0.exe

Seven partner countries (Denmark, Germany, Hungary, Italy, Poland, Romania, and Sweden) in the DQME II project have decided to do the same modeling exercise during 2008-2009.

Objectives: To learn more about trigonometric functions

Task: Find a table with values for the sunrise and sunset of your town.

1. Use a suitable tool to draw a graph of these data

2. Determine a suitable function that could be used to model this data. Explain the assumptions you are making.

3. Identify parameters and variables that need to be determined.

4. Use a suitable tool to find a function that fits your data. Comment and critique any differences with the result from 2, and 3.

5. Make a task concerning switching on and off nightlight according to your model.

6. How would your model change if you went to (Roskilde, Copenhagen, Gothenburg, Cluj Napoca, Warszawa,...)

Reference

Lingefjärd, T. (2006). Faces of mathematical modelling. *ZDM, 38*(2), 96-112.

Research Publication from project:

The paper will be published in:

Blomhøj, M. & S. Carreira, (Eds.) (2009). *Different perspectives in research on teaching and learning mathematical modeling*. Proceeding from Topic Study Group 21 at ICME-11 in Monterrey, Mexico. IMFUFA-text no. 461, Department of Science, Systems and Models, Roskilde University.

Thomas Lingefjärd

5.2 Research on Educative Curriculum Materials

A research project funded by CNPq Brazilian Research Funding Council is going to examine the impact of modelling-based educative curriculum materials on teachers' pedagogic practice. The team of the project is based at the NUPEMM Mathematical Modelling Research Group of the State University of Feira de Santana, Brazil (www.uefs.br/nupemm), coordinated by Jonei Cerqueira Barbosa. Also, the project has Pauline Vos, from the University of Amsterdam, as collaborator, so establishing the project as a transnational enterprise.

Educative curriculum materials are those designed to promote students' learning as well as teachers' learning. These materials are expected to go beyond guiding. They should provide clues, accounts, and information that make teachers more comfortable to implement an educational innovation in their school contexts. In order to achieve such features, the materials are based on teacher's knowledge.

The project involves designing the materials by a team composed of scholars and school teachers. Next, teachers who do not have previous contact with modelling will be motivated to use those materials. The research team will be able to gather evidence about the affordances about the role that educative materials can play in implementing modelling in classrooms. The project team is looking forward to sharing the results in coming ICTMAs.

Jonei Barbosa

6. Recent Dissertations

Cirilo, Kassiana Schmidt Surius (2008). *Livros didáticos e modelagem matemática: uma caracterização da transposição didática da integral (Textbooks and mathematical modelling: a characterization of the didactic transposition of the integral)*. **Unpublished Máster dissertation. Londrina, Brazil: State University of Londrina. Supervisor: Lourdes Maria Werle de Almeida.**

This research shows an investigation about the Didactic Transposition of the contents of the Differential and Integral Calculus in text books and in activities of Mathematical Modelling. The study is reasoned in the Yves Chevallard's theory about Didactic Transposition and in the Mathematical Modelling as a pedagogical alternative. We established previously three attributes of the Didactic Transposition. The investigation has as aim to infer if these attributes are observed in the transposition of the content of integral in text books and in Mathematical Modelling activities. We analyzed the books of *Calculus* by George Thomas Jr. and *A Course of Calculus* by Hamilton Guidorizzi and four activities of Mathematical Modelling. We noticed that the attributes are contemplated partially in the text books and in the Modelling activities, however the contemplated aspects are different. These data permitted the noticing of the fact that the advantages and disadvantages of working mathematical concepts by means of activities of Mathematical Modelling and text books and the potentiality of the association of the book and the activities for the teaching of the Differential and Integral Calculus.

Malheiros, Ana Paulo dos Santos (2008). *Educação Matemática online: a elaboração de projetos de Modelagem (Online mathematics education: elaborating modelling projects)*. **Unpublished PhD dissertation. Rio Claro, Brazil: State University of Sao Paulo. Supervisor: Marcelo de Carvalho Borba.**

The research question addressed in this study was "How does the elaboration of modelling projects take place in the virtual learning environment of a distance course?". The elaboration of modelling projects by mathematics teachers was studied throughout a university extension course entitled "Trends in Mathematics Education: emphasis on mathematical modelling", proffered entirely at a distance using a virtual learning environment called TIDIA-Ae. A qualitative research methodology was used, characterised by harmony between the view of knowledge production, in this case based on the theoretical construct humans-with-media, and methodological procedures used. Using this approach, the media used in the elaboration of the projects and the roles they played in the process were identified. Elements of collaborative work in this context were also considered and factors identified that condition the complete elaboration of the modelling projects. The results suggest that, in the context studied, collaboration took place through dialogue and interaction, made possible by the different media, throughout the process of elaboration of the modelling projects, and that collectives of humans-with-media promoted collective intelligence in order to elaborate the projects; the individual interests of the participants conditioned the elaboration of the modelling projects, in the sense that themes were proposed and negotiated between the pairs of students; information and communication technologies (ICT) were protagonists throughout the entire process of elaboration of the modelling projects, used as means for research and communication, as various strategies were developed by the teacher-students based on the possibilities of the ICT and their need to understand. The preoccupation with mathematical contents and the difficulty of choosing a theme to investigate illustrate the difficulties of the participants (teachers), to elaborate modelling projects in the role of student; advising, which is a very necessary part of project work in the educational context, was present throughout the process of elaboration of modelling projects in the distance course, in various ways and at different levels.

Santos, Fabio Vieira dos (2008). *Modelagem Matemática e Tecnologias de Informação e Comunicação: o uso que os alunos fazem do computador em atividades de Modelagem Matemática (Mathematical modelling and technologies of information and communication: the use that students do of the computer in modelling activities)*. **Unpublished Master dissertation. Londrina, Brazil: State University of Londrina. Supervisor: Lourdes Maria Werle de Almeida.**

In this work we presented an investigation about activities of Mathematics Modelling mediated by the use of the computer. The information presented in our research were obtained in the period from 13/04/2007 to 10/08/2007, starting from encounters with students who were studying the discipline of Differential Calculus and Integral II in a mathematics' degree course. In those encounters Modelling activities were developed so that we could make analyses of the students' performances during the accomplishment of those activities. The methodological procedures used in our research are based on the principles of the Romberg's proposal and the Teaching Experiments, and the information collected allowed us to verify the use that the students made of

the computer in the exploration or construction of a mathematical model, as well as to observe aspects that can contribute to learning of Mathematics. Moreover, they gave signals that the combination of Modelling with the Information and Communication Technologies (ICT), especially with the computer, promotes understanding and encourages activities that contribute to the development of creativity with regard to the search for solutions to current problems that society may place.

Silva, Karina Alessandra Pessoa (2008). *Modelagem matemática e semiótica: alguma relações (Mathematical modelling and semiotics: some relations).* **Unpublished Master dissertation. Londrina, Brazil: State University of Londrina. Supervisor: Lourdes Maria Werle de Almeida.**

In this work, we presented a research study based in the theoretical presuppositions of the Mathematical Modelling in the perspective of the Mathematics Education and trying to establish relations between this perspective and the Semiotics from Peirce and the Theory of Semiotics Representation Registers from Raymond Duval. For this purpose, we analysed three activities of Mathematical Modelling in the literature: one within the group of studies in which the research is inserting, one within the national arena drawing on the procedures of the Fifth National Conference on the Modelling in Mathematics Education and one within the international research arena drawing on the procedures of the International Conference on the Teaching of Mathematical Modelling and Applications. The research consists in a documentary analysis of the registers presented by the author/model of each activity of Modelling selected. From the analysis some relations between Mathematical Modelling and Semiotics have beeen established, with respect to the categorisation of signs established by Peirce, the modes of inference of signs classified by Kehle and Cunningham (2000), the semiotics representation registers approached by Duval with respect to the phenomenon of congruence and non-congruence of conversions between the registers and the tasks of production and understanding.

West, K.I. (2005). *Japanese high school mathematics teacher competence in real world problem solving and its implication for the use of modeling to improve Japanese mathematics education.* **PhD. Columbia University. Supervisor: Prof. Bruce R. Vogeli.**

The purpose of this qualitative study was to obtain evidence of the competence of high school mathematics teachers in Japan to implement activities involving mathematical modelling in high school mathematics. Data were collected through clinical interviews and self reported problem solving. Although the sample was small (7), the uniformity of preparations of Japanese high school teachers may allow findings to be indicative of a large population.

Problems of mathematical modelling were taken from American pre-calculus and first year calculus textbooks. All seven mathematics teachers of a Japanese public high school returned answers to the problems mailed to their principal, and four of them participated in the group interview conducted at the school. Opinions of another three teachers were collected by the school principal and given to the author over the telephone. The problem answers and the interview revealed these teachers to be competent in dealing with modelling problems even though they were not familiar with the concept of modelling. Teachers maintained study meetings, which coincidentally included modelling type problems, illustrating their inherent interest in modelling. One reason teachers do not teach modelling in class, despite their positive attitude, was that college entrance examinations did not include modelling problems at the time.

Fostering creativity is a major issue in Japanese mathematics education and mathematical modeling is recommended as a tool to facilitate this. A comparative study of mathematics classrooms in the United States, China and Japan shows that Japanese elementary school students are exposed to real world problems the most (Stigler & Perry, 1990). PISA, an international study, shows that Japanese fifteen year olds, students in the first year of high schools, are highly capable of applying mathematics to real-life situations. In addition to the students' readiness for the introduction of mathematical modelling indicated in those studies, this study indicates that teachers have the mathematical competence to learn and to teach mathematical modelling.

7. Recent Publications of Interest

Andresen, M. & Lindenskov, L. (2009). New roles for mathematics in muti-disciplinary, upper secondary school projects. *ZDM—The International Journal on Mathematics Education, 41*(1-2), 213-222.

Blomhøj, M. & Hoff Kjeldsen, T. (2009). Project organized science studies at university level: Exemplarity and interdisciplinarity. *ZDM—The International Journal on Mathematics Education, 41*(1-2), 183-198.

Bülent Çetinkaya, B., ςen, A. & Baς, S. (2008). Integrating mathematical modeling and technology in teaching and learning mathematics. In *Proceedings of 8th International Educational Technology Conference* (pp..241-246) held at Anadolu University, Eskiςehir, Turkey. Available from http:www.ietc2008.anadolu.edu.tr/online.php

Doerr, H. M., & Pratt, D. (2008). The learning of mathematics and mathematical modeling. In M. K. Heide & G. W. Blume (Eds.*), Research on technology and the teaching and learning of mathematics: Vol.1 Research syntheses* (pp. 259-285). Charlotte, NC: Information Age Publishing.

Doorman, L. M., & Gravemeijer, K. P. E. (2009). Emergent modeling: Discrete graphs to support the understanding of change and velocity. *ZDM—The International Journal on Mathematics Education, 41*(1-2), 199-211. [Open Access]

English, J. (2009). Promoting interdisciplinarity through mathematical modeling. *ZDM—The International Journal on Mathematics Education, 41*(1-2), 161-181.

de Loiola Araújo, J. (2008). Contradictions in mathematical modelling activities from a critical mathematics education perspective In J.F. Matos, P. Valero & K. Yasukawa (Eds.), *Proceedings of the Fifth International Mathematics Education and Society Conference*. Lisbon: Centro de Investigação em Educação, Universidade de Lisboa – Department of Education, Learning and Philosophy, Aalborg University.

Höfer, T. & Beckmann, A. (2009). Supporting mathematical literacy: Examples from a cross-curricular project. *ZDM—The International Journal on Mathematics Education, 41*(1-2), 223-230.

Hoff Kjeldsen, T. & Blomhøj, M. (2009). Integrating history and philosophy in mathematics education at university level through problem-oriented project work. *ZDM—The International Journal on Mathematics Education, 41*(1-2), 87-103.

Le Roux, K. (2008). A critical discourse analysis of a real-world problem in mathematics: Looking for signs of change. *Language and Education, 22*(5), 307-326.

Michelsen, C. & Sriraman, B. (2009). Does interdisciplinary instruction raise students' interest in mathematics and the subjects of the natural sciences? *ZDM—The International Journal on Mathematics Education, 41*(1-2), 231-244.

Mousoulides, N. G., Christou, C., Sriraman, B. (2008). A modeling perspective on the teaching and learning of mathematical problem solving. *Mathematical Thinking and Learning, 10*(3), 293 – 304.

Nuhoglu, H. (2008). Modeling spring mass system with system dynamics approach in middle school education. *The Turkish Online Journal of Educational Technology, 7*(3), 22-34. [Available at: www.tojet.net]

Peled, I. (2008). Who is the boss? The roles of mathematics and reality in problem solving. In J. Vincent, J. Dowsey & R. Pierce (Eds.), *Connected maths*, Proceedings of the Forty-fifth annual conference of the Mathematical Association of Victoria (pp. 274-282). Melbourne: MAV.

Rowlands, S. (2008). Why mechanics should be integral to secondary school mathematics. *Teaching Mathematics and its Applications, 27*(4), 187-199.

Mechanics has never been the most popular subject in A-level mathematics, the UK's public examination for 16–18-year olds, either with students, teachers or educators. The attempts to popularize mechanics have failed and it is conceivable that the subject will be dropped from the A-level syllabus in the foreseeable future. This article argues the importance of mechanics and why it should be integral to secondary school mathematics: Mechanics is the exemplar of mathematical modelling, is the logical point of entry for the enculturation into scientific thinking and provides the means to develop an understanding of the relationship between mathematics, the theoretical objects of science and the way science and mathematics speak of the world. It enables learners across the 'ability range' to think in the abstract and as such should be taught prior to the 6th form, that is, prior to the UK's post-compulsory level of education.

Savizi, B. (2006). Applicable problems in history of mathematics; Practical examples for the classroom. *Philosophy of mathematics Education Journal, 19*(Dec). [Available from: http://people.exeter.ac.uk/pome19/]

Schwarz, B., Wissmach, B., & Kaiser, G. (2008). "Last curves not quite correct": Diagnostic competencies of future teachers with regard to modelling and graphical representations*. ZDM—The International Journal on Mathematics Education, 40*(5), 777-790.

The article describes the results of a national enrichment to the six-country study *Mathematics Teaching in the 21st century (MT21)*—an international comparative study about the efficiency of teacher education. The enrichment focuses on the diagnostic competence of future mathematics teachers as sub-component of teachers' professional competence for which the evaluation of students' solutions of a modelling task about the course of a racetrack is demanded. In connection with two sub-facets of the diagnostic competence, namely the competence to recognise students' misconceptions and the competence of criteria-guided assessment of students' solutions, typical answer patterns are distinguished as well as the frequency of their occurrence with regard to future teachers' phase of teacher education and the level of school teaching they are going to teach in.

Sriraman, B., Michelsen, C., Beckmann, A., & Freiman, V. (Eds.). (2008). Interdisciplinary educational research in mathematics and its connections to the Arts and Sciences. Charlotte, NC: Information Age Publishing.

Stillman, G. (2008). Connected mathematics through mathematical modelling and applications. In J. Vincent, J. Dowsey & R. Pierce (Eds.), *Connected maths*, Proceedings of the Forty-fifth annual conference of the Mathematical Association of Victoria (pp. 325-339). Melbourne: MAV.

Voges, E.L., & Joubert, S. V. (2008). The singing wineglass: an exercise in mathematical modelling. *International Journal of Mathematical Education in Science and Technology, 39*(6), 725–739.