

TSG Agenda

TSG 22: Mathematical applications and modelling in mathematics education

Class: B, Session 0 (additional): 14:30-16:30 Beijing time, July 13th

Session 0 (additional)

14:30-16:30 Beijing time, July 13th

1. Time: 14:30—14:45 (Session 0)

Title of the Paper: INTRODUCTION (online)

Author(s): **Team TSG 22**

2. Time: 14:45—15:05 (Session 0, Overview)

Title of the Paper: THE TEACHING AND LEARNING OF MATHEMATICAL MODELLING A DESCRIPTION OF THE CURRENT STATE-OF-THE-ART (online)

Author(s): **Gabriele Kaiser**

Institution(s) and Country/Region: University of Hamburg, Germany

Short abstract of the paper: The paper describes briefly the current state-of-the-art on the teaching and learning of mathematical modelling. The lines of development are identified along the discussions, which have taken place mainly at past ICMEs or ICTMAs and are enriched by an extensive additional literature review of the most recent discussion on mathematical modelling and its teaching and learning. As a main result, it can be pointed out that on the one hand, there exists a high number of empirical studies on the teaching and learning of mathematical modelling, however, on the other hand, there is a strong

need for more studies with clear conceptualisations following rigorous standards. Compared to the situation at the beginning of the development of the field the number of theoretical papers has decreased strongly reflecting the global empirical wave in mathematics education

3. Time: 15:05—15:10 (Session 0, Overview)

Discussion

4. Time: 15:10—15:20 (Session 0, Teaching mathematical modelling)

Title of the Paper: SOCIOCULTURAL INFLUENCES ON MATHEMATICAL MODELLING: AN ETHNOMATHEMATICAL PERSPECTIVE (online)

Author(s): **Milton Rosa**, Daniel Clark Orey

Institution(s) and Country/Region: Universidade Federal de Ouro Preto, Brazil

Short abstract of the paper: A major problem with contemporary mathematics education is its overwhelming bias towards a Western orientation in both overall values, topics and research paradigms. A search for new approaches and methodologies is necessary to record historical forms of mathematical ideas that occur in different sociocultural contexts, and to take advantage of the an emerging glocalization of business, science, religion, art, music and other aspects of culture. There is a need to apply a fundamentally different philosophy, modelling techniques, and an ethnomathematical perspective to mathematics curriculum. We propose to demonstrate how ethnomodelling as a pedagogical action for teaching and learning of mathematics challenges the traditional prevailing ways of thinking and doing mathematics.

5. Time: 15:20—15:30 (Session 0, Teaching mathematical modelling)

Title of the Paper: TEACHING METHODS FOR MODELLING PROBLEMS (online)

Author(s): **Stanislaw Schukajlow, Werner Blum**

Institution(s) and Country/Region: University of Muenster, University of Kassel,
Germany

Short abstract of the paper: Despite of the importance of the ability to solve modelling problems for students lives, various studies have demonstrated that students all over the world have considerable difficulties in solving modelling problems. An important goal of mathematics education is thus to develop and to examine teaching methods for modelling problems. On the basis of a literature review, we identified guided instruction and a constructivist view of teaching as two important general principles of such teaching methods. We discuss these general principles by referring to teaching methods that were developed in our own projects DISUM and MultiMa. These teaching methods varied in the degree of guidance given by teachers or learning materials, on the one hand, and in the degree of self-regulation experienced by the students, on the other hand. The effects of these teaching methods on students achievement and attitudes were evaluated in a series of empirical studies, and we investigated under which conditions these teaching methods work. Finally, we discuss challenging points for future research on teaching methods for modelling.

6. Time: 15:30—15:35 (Session 0, Teaching mathematical modelling)

Discussion

7. Time: 15:35—15:40 (Session 0, Teaching mathematical modelling)

Title of the Paper: EXAMINING THE GEOGRAPHICAL FEATURES OF THE NASU AREA ANALYZING THE ORIGIN OF THE NASU AREA USING MATHEMATICS (online)

Author(s):**Masahiro Takizawa**

Institution(s) and Country/Region: Otawara Senoior High School, Otawara City, Japan

Short abstract of the paper: The Nasu Area is part of the Nikko National Park in Japan. The author obtained 13,500,000 (3,000 lines times 4,500 columns) points of altitude data on the Nasu Area from the Geographical Survey Institute. By mathematically processing them on a computer, difference geographical properties could be found. These materials show how mathematics reveals these properties from big data by constructing statistical models. These materials show several modeling processes, which start with unclear geographical presumptions. (e.g. what can be said by calculating the standard deviation of the altitude in mountainous environment?) However, they change into unexpected but clear ones by the models. The students gain interest in geography through mathematics. This study analyzes such particular modelling processes.

8. Time: 15:40—15:45 (Session 0, Teaching mathematical modelling)

Title of the Paper: A MATHEMATICAL MODELLING TECHNIQUE AS TOOL FOR TEACHING MATHEMATICS (online)

Author(s):**Eloisa Benitez-Mariño**

Institution(s) and Country/Region: Universidad Veracruzana, Xalapa, Mexico

Short abstract of the paper: In this paper, we show a mathematical technique, which can be used as a tool for teaching mathematics at the university level, with emphasis in education of engineering, economic and business sciences. We observe that, this mnemonic technique gives us a procedure that helps to generate reflective process of mathematical modelling, which implies that we should not limit only to the teaching of

mathematics immersed in a phenomenon or interpretation. Even more, we must pay attention to methodological practices involve, in this process and underlying mathematical language. Thus, mathematical concepts emerge naturally. When the technique of mathematical modelling is used in a classroom, with undergraduate students, where the following paradigm is changed: first, teaching math and after study the applications. Here, in the opposite direction, a verbal problem is presented and during the process of construct and solve of model, mathematical concepts are studied and students development a collection of skills.

9. Time: 15:45—15:50 (Session 0, Teaching mathematical modelling)

Title of the Paper: THEORIZING TENSIONS BETWEEN MATHEMATICAL MODELING PROCESSES AND CONVENTIONAL MATHEMATICS INSTRUCTION (online)

Author(s): **Wenmin Zhao**, Samuel Otten

Institution(s) and Country/Region: Guangdong University of Education, Guangzhou, China

Short abstract of the paper: In this article, we refine and illustrate the mathematical modeling framework developed by Blum and Leiss (2005) in order to characterize the ways in which the processes of mathematical modeling depart from conventional secondary classroom practices in the United States. Our analysis shows that modeling is different from conventional mathematical instruction in emphasizing students' non-mathematical thinking, allowing for students' decision making (i.e., selecting information, mathematical components, and representation types), and encouraging evaluation and revision. Efforts to support teachers in enacting mathematical modeling should account for these departures.

10. Time: 15:50—15:55 (Session 0, Teaching mathematical modelling)

Discussion

11. Time: 15:55—16:00 (Session 0, Teaching mathematical modelling)

Title of the Paper: THE RATIONALES OF STATISTICAL MODELLING IN EDUCATION RESEARCH FROM A MATHEMATICAL MODELLING PERSPECTIVE (online)

Author(s): **Takashi Kawakami**, Jonas Bergman Arleback

Institution(s) and Country/Region: Utsunomiya University, Japan

Short abstract of the paper: In this paper, we develop and discuss a framework for characterising the rationales of statistical modelling (SM) in educational research from a mathematical modelling perspective. We report some results from a systematic literature review of empirical research on SM departing from the dual rationale of modelling in mathematics education as a means for developing competencies and as a means for learning contents. The results are presented and exemplified in three identified categories of rationales of SM in terms of competency-, content-, and society-oriented types.

12. Time: 16:00—16:05 (Session 0, Teaching mathematical modelling)

Title of the Paper: MODELLING IN A TEACHER EDUCATION PROGRAMME (online)

Author(s): **Dragana Martinovic**

Institution(s) and Country/Region: University of Windsor, Canada

Short abstract of the paper: In this paper I describe results of a teaching experiment in which the future upper elementary and secondary school teachers organize modelling activities for their peers. After introducing a teacher education context as well as the related curriculum in Ontario, Canada, I summarize lessons learned about pedagogical, content and technological aspects of modelling activities, compare them to the findings in

the literature, and identify some practices that could enhance mathematics teacher education.

13. Time: 16:05—16:15 (Session 0, Teaching mathematical modelling)

Discussion

14. Time: 16:15—16:30 (Session 0)

POSTER PRESENTATION (online)

Author(s): **Team TSG 22**

Session 1

19:30-21:00 Beijing time, July 13th

15. Time: 19:30—19:40 (Session 1, Teacher education)

Title of the Paper: MATHEMATICAL MODELING IN STEM CONTEXTS.
CHARACTERIZATION OF STEM SKILLS AND GENDER GAPS IN INITIAL
FORMATION OF MATHEMATICS TEACHERS (online)

Author(s): **María Aravena Diaz**, Marcelo Alejandro Rodriguez, Susan Valeria Sanhueza
Henriquez, Maria Jose Seckel, Angelica Urrutia Seplveda

Institution(s) and Country/Region: Catholic University of Maule, Talca, Chile

Short abstract of the paper: The study, funded by the Fund of Research and Development in Education of Chile (FONIDE 1700070), addressed gender diversity in the training of mathematics teachers in STEM skills. The framework considers gender gaps in these skills and the need to look for strategies that enhance these skills in teacher training. In the experiment, future teachers formulated and solved modeling problems with a STEM approach, favoring local contexts. The sample consisted of 31 professors who met the criteria of belonging to the 6th academic semester, and to analyze the gender gaps, the Mann-Whitney U and Wilcoxon test were used. For characterize the skills they develop, main components and support vector machine. The findings show that, at the end of the experiment, there are significant differences in the development of skills and that there are no gender gaps when they are formed in STEM contexts.

16. Time: 19:40—19:50 (Session 1, Teacher education)

Title of the Paper: CORRESPONDENCE VERUS COVARIATION PERSPECTIVES WHILE MODELING GLOBAL WARMING (Presentation not confirmed)

Author(s): **Dario Andres Gonzalez**

Institution(s) and Country/Region: Universidad de Chile, Santiago, Chile

Short abstract of the paper: I contrast two preservice teachers (PSTs) ways of conceiving relations between quantities the correspondence perspective versus the covariation perspective while modeling global warming. The PSTs completed a mathematical modeling task during an individual, task-based interview. The study shows that the covariation perspective better supports the modeling activity compared to the correspondence perspective. The study found that the covariation perspective supported anticipating concavity, drawing an accurate graph by envisioning continuous and smooth change, and reasoning about the rate of change, all important abilities when modeling relations between quantities (Thompson, 2011).

17. Time: 19:50—19:55 (Session 1, Teacher education)

Discussion

18. Time: 19:55—20:00 (Session 1, Teacher education)

Title of the Paper: USING ASSESSMENT FOR LEARNING TO SUPPORT STUDENTS MODELLING ACTIVITIES (online)

Author(s): **George Ekol**

Institution(s) and Country/Region: University of Witwatersrand, Johannesburg, South Africa

Short abstract of the paper: This paper explores the assessment for learning as a strategy to maximize students' gains in mathematical modelling education. Data are collected from 52 final year pre-service mathematics teachers offering modelling as an option in their undergraduate mathematics programs. Preliminary data collected at the beginning of the course showed that about 90 percent of the students who participated in the survey, expressed fear of failing mathematical modelling course. This finding influenced the choice of instruction by the course instructor, toward assessment for learning. Based on the assumption that assessment for learning continuously helps build students' confidence in themselves as learners and helps them take responsibility for their own learning, it is expected in the current study, that the mean score in the final examinations will be higher than the mean score in the course assessment tests.

19. Time: 20:00—20:05 (Session 1, Teacher education)

Title of the Paper: EPISTEMIC STATES OF UNIVERSITY MATHEMATICS TEACHERS IN MATHEMATICAL MODELLING EDUCATION (online)

Author(s): **George Gotoh**, Mitsuru Kawazoe, Hirofumi Ochiai

Institution(s) and Country/Region: Niigata University, Japan

Short abstract of the paper: In mathematical modelling education, it is not enough only to use mathematics in real-world situations. In the design of a meaningful class, M. Artigue emphasized the importance of epistemological analysis to find a *raison d'être* of

mathematical knowledge to be taught. In the previous study, we developed an epistemic framework for the use of grasping the *raison detre* of mathematical knowledge in real-world situations, and a design of mathematics modelling education based on it. However, the verification of its effectiveness has been a challenge. In this study, we conducted an interview survey using semi-structured methods with four teachers engaged in mathematical modelling education in order to find out if the epistemic framework we developed is useful for the practice and improvement of mathematical modelling education. A qualitative analysis of their answers suggested that for experienced teachers, the framework gives a verbalization of what they are doing unconsciously, and it can be useful in designing meaningful classes. On the other hand, for inexperienced teachers, only the framework is not enough, something that supports their teaching design and practice is necessary.

20. Time: 20:05–20:10 (Session 1, Teacher education)

Title of the Paper: USING STAGED VIDEOS TO FOSTER PRE-SERVICE TEACHERS NOTICING SKILLS (online)

Author(s): **Alina Alwast**, Katrin Vorhölter

Institution(s) and Country/Region: University of Hamburg, Germany

Short abstract of the paper: Recent conceptualizations of teachers competencies focus not only on teachers dispositions but also include situated competence facets. Being able to perceive and interpret situation-specific aspects is especially important when dealing with mathematical modelling as students encounter a variety of obstacles, which cannot always be anticipated. The study described in this paper aims at fostering and measuring those situated skills in the context of mathematical modelling and links them to pedagogical content knowledge on mathematical modelling. With a sample of presumably 50 pre-service teachers in their masters studies an intervention is conducted, in which the participants acquire not only knowledge about mathematical modelling but also practice their noticing skills through the repeated analysis of videos. As the pilot study suggested relations between situation-specific skills and modelling-specific pedagogical content knowledge, these connections will be further analyzed.

21. Time: 20:10—20:20 (Session 1, Teacher education)

Title of the Paper: PROSPECTIVE TEACHERS SELF-EFFICACY FOR TEACHING MATHEMATICAL MODELLING (online)

Author(s): **Hans-Stefan Siller, Gilbert Greefrath**, Raphael Wess, Heiner Klock

Institution(s) and Country/Region: University of Wuerzburg, University of Muenster, Germany

Short abstract of the paper: In the teacher training for modelling, we focus on the professionalisation of prospective teachers through reflective practice. To do so, we consider teachers self-efficacy beliefs as an important aspect of professional competence for teaching mathematical modelling. A pre-/post design was used to examine the extent to which self-efficacy of mathematics teacher-training students for mathematical modelling can be increased through a variety of different teaching-learning laboratories. Clear effects can be seen if the students themselves create the modelling tasks for use with schoolchildren.

22. Time: 20:20—20:30 (Session 1, Teacher education)

Discussion

23. Time: 20:30—20:35 (Session 1, Teacher education)

Title of the Paper: PEDAGOGY THAT SUPPORTS MATHEMATICAL MODELING ONE ELEMENTARY SCHOOL TEACHERS STORY (online)

Author(s): **Rejoice Akapame**, Robin Angotti

Institution(s) and Country/Region: University of Washington Bothell, United States of America

Short abstract of the paper: Mathematical modeling by nature requires innovative pedagogical strategies such as collaborative group work interspersed with different formative assessment techniques. In this research study, one elementary school teacher, implemented mathematical modeling tasks to teach number sense, geometry, algebra, and linear modeling. The teacher made changes to the content and used collaborative learning combined with formative assessment practices after participating in a year-long professional development program focused on mathematical modeling and pedagogy. Analysis of assessment results using a t-test showed significant gains with the largest increase in mathematics achievement being realized by students classified below proficient and those enrolled in special education.

24. Time: 20:35—20:40 (Session 1, Teacher education)

Title of the Paper: PRE-SERVICE MATHEMATICS TEACHERS PROJECT-BASED MATHEMATICAL MODELING INSTRUCTION: CONCEPTON, TASK DESIGN, AND ENACTMENT (online)

Author(s): **JooYoung Park**

Institution(s) and Country/Region: Florida institute of technology, Melbourne, United States of America

Short abstract of the paper: This exploratory study examined pre-service secondary mathematics teachers conception of project-based mathematical modeling instruction,

view of tasks, and challenges with the instruction. Data sources were open questionnaires, reflection journals, lesson plans, interviews, and video-recorded classroom observations. Findings indicated that the pre-service teachers views were reflected in their task designs focusing on developing ability of learners to apply mathematics to solve practical real life problems. The participants reported that making a decision about task constraints and anticipating students challenges were the most difficult part of their lesson planning. The participants pedagogical content knowledge for modeling instruction appears to be superficial. Full paper will report the details on participants project lessons and implementations.

25. Time: 20:40—20:45 (Session 1, Teacher education)

Title of the Paper: THE DEVELOPMENT OF A MODELLING TEACHER EDUCATION PROGRAM STARTING FROM THE TRANSFORMATION OF A MATHEMATISED TASK INTO MODELLING TASKS (online)

Author(s): **Akihiko Saeki**, Masafumi Kaneko, Takashi Kawakami, Toshikazu Ikeda

Institution(s) and Country/Region: Naruto University of Education, Yokohama National University, Japan

Short abstract of the paper: Most Japanese teachers have little experience of modelling, and little research exists on teacher training of mathematical modelling in Japan. Therefore, we developed a modelling teacher education program starting from the transformation of a mathematised task into modelling tasks. In this paper we describe a framework of the transformation of a mathematised task into modelling tasks, as well as the design for modelling lessons. Furthermore, we will illustrate the relationship between the activities in this program and key competencies for teaching mathematical modelling.

26. Time: 20:45—20:50 (Session 1, Teacher education)

Title of the Paper: PROSPECTIVE TEACHERS OF MATHEMATICS SUSPEND COMMON SENSE IN SOLVING WORD PROBLEM (online)

Author(s): **Abolfazl Rafiepour**, Zohreh Khazaei

Institution(s) and Country/Region: Shahid Bahonar University of Kerman, Iran

Short abstract of the paper: Many studies have shown that, in general, students do not use real-world knowledge and common sense when solving problematic word problem. The behavior of the teacher and the method of solving these problems in the classroom is one of the possible factors for unrealistic responses to such problems. Considering the importance of this issue, in the present study, tries to get attention and apply real-world considerations related to this problems. In this study, 110 prospective teachers from two university participated. The results revealed a strong tendency among prospective teachers to do not use their real world knowledge. Results of this study classified prospective teachers responses to problematic word problem.

27. Time: 20:50—21:00 (Session 1, Teacher education)

Discussion

Session 2

21:30-23:00 Beijing time, July 16th

28. Time: 21:30—21:35 (Session 2, Students modelling competency)

Title of the Paper: THE MATHEMATICAL MODELLING LANDSCAPE: A LITERATURE REVIEW ON PERSPECTIVES, METHODOLOGY, CONTENT, UNIT OF ANALYSIS, AND GEOGRAPHY (online)

Author(s): **Armando Paulino Preciado Babb**, Fredy Peña Acuña, Andrea Ortiz Rocha, Armando Solares Rojas

Institution(s) and Country/Region: University of Calgary, Canada

Short abstract of the paper: We offer an analysis of the literature on mathematical modelling complementing previous states of the art. The review included 441 documents from two sources: articles published in relevant journals, and specific books emanated from both the conference organized by the International Community of Teachers of Mathematical Modelling and Applications and the ICME conference. The analysis focused on mathematical modelling perspectives, research methodology, mathematical content, unit of analysis, and country of authors institution. We identified categories in each of these variables and report the corresponding frequencies. The results are compared with and contrasted to other states of the art, stressing the specific contribution of this review.

29. Time: 21:35—21:45 (Session 2, Students modelling competency)

Title of the Paper: DISTINGUISHING THE DISTINCTIONS: OBSERVING THE SOLVING OF A MATHEMATICAL MODELLING TASK (online)

Author(s): **Paola Andrea Ramirez Gonzalez**

Institution(s) and Country/Region: Universidad de Talca, Chile

Short abstract of the paper: From an observer perspective and based on an enactivist approach, this methodological paper presents my distinctions of the distinctions that a mathematics teacher and her students (1314-year-olds) made when they were solving a mathematical modelling task for the first time. These distinctions include the students comparison of the modelling task with the usual way of solving mathematical problems and the teachers noting a specific mathematical factor when she was solving the problem, which she later replicated in the classroom with her students triggered similar behaviour between them.

30. Time: 21:45—21:50 (Session 2, Students modelling competency)

Discussion

31. Time: 21:50—21:55 (Session 2, Students modelling competency)

Title of the Paper: MATHEMATICAL MODELLING SKILLS OF SECONDARY STUDENTS (online)

Author(s): **Kwan Eu Leong**

Institution(s) and Country/Region: University of Malaya , Kuala Lumpur, Malaysia

Short abstract of the paper: Problem solving is one of the important skills tested in the mathematics classrooms. However, formulation of problems is even more important in 21st-century learning. In mathematical modelling, solving real-world problems requires students to not only make suitable assumptions but to also formulate models to solve them. These important skills would prepare students to be successful when they join the workforce. This study aims at identifying the modelling skills of secondary students. The mathematical modelling instrument consists of modelling tasks. Participants of this study were 125 students from several schools in Selangor, Malaysia. The results showed that

many students have difficulty solving mathematical modelling tasks. Students performed best in the using mathematics skill but performed poorly in other skills such as understand the modelling task, establishing models and validating results. This study suggests that students need to be exposed to more modelling tasks in order for them to develop their modelling skills.

32. Time: 21:55—22:05 (Session 2, Students modelling competency)

Title of the Paper: MATHEMATICAL MODELING IN THE NEW CURRICULUM: ARE CHINESE STUDENTS READY? (in Shanghai)

Author(s): **Jian Huang**, Binyan Xu

Institution(s) and Country/Region: EAST CHINA NORMAL UNIVERSITY, Shanghai, China

Short abstract of the paper: In the newly issued national curricular standards for high school mathematics in China, mathematical modeling competence (MMC) has been recognized as one of the six core competencies for students to develop through the learning and teaching of school mathematics. This study investigates the historical development of mathematical modeling (MM) in China curricula, employs qualitative text analysis approach to analyze the mathematics curricular syllabi/standards at primary, middle and high school levels in China. At the same time, we select 3 MM problems to test the MMC of 1,428 eighth-grade students in five cities of China, then we double-coded and analyze the survey data from two dimensions: steps of mathematical modeling building (MMB) & ability of mathematical modeling (MMAB). It was found that the learning and teaching requirements of MM in the curricular standards are more and more specific and strict. From the data, in the MMB, most students stay at the step 4; in the MMAB, on the M1 and M2 test problems, most students are able to reach level 5, while M3, most students can only reach level 3. The performance of students' MMC is influenced by the difficulty of MM problems.

33. Time: 22:05—22:15 (Session 2, Students modelling competency)

Title of the Paper: STUDENT PRESENTATIONS OF MATHEMATICAL MODELLING AS A SITE FOR FOSTERING REFLECTIVE DISCOURSE (online)

Author(s): **Hyunyi Jung**, Corey Edison Brady, Jeffrey Allen McLean, Angeles Dominguez, Aran Glancy

Institution(s) and Country/Region: Marquette University, Korea

Short abstract of the paper: How can mathematical modelling presentations act as opportunities for students to engage in reflective discourse? And, what teacher facilitation moves can initiate discourse shifts toward reflective discourse in this setting? To address these questions, video and student artefacts from a mathematical modelling summer camp involving a diverse group of 21 students were analysed using the constant comparison (Glaser, 1965) method. We found that presentations could provide a forum for reflective discourse, where teachers facilitation moves were consequential. Using a sample episode, we illustrate how reflective discourse emerged within a single mathematical modelling activity during student presentations. This contrasts with prior work that suggests a sequence of related activities are required to promote reflective discourse.

34. Time: 22:15—22:20 (Session 2, Students modelling competency)

Discussion

35. Time: 22:20—22:25 (Session 2, Students modelling competency)

Title of the Paper: HOW DO UNDERGRADUATE STUDENTS HOLD THE INDIVIDUAL ASSUMPTIONS IN COLLABORATIVE MODELLING? (online)

Author(s): **Kazuhiko Imai**

Institution(s) and Country/Region: Graduate school of education, Saitama University, Kawagoeshi,, Japan

Short abstract of the paper: A research question is how do the undergraduate students hold individual assumptions in collaborative modelling? The aim of this paper is to clarify how do undergraduate students hold individual assumptions in collaborative modelling from a modelling lesson we practiced. From case study, we describe the conclusions as follows: there are individual assumptions were rejected and keep holding, if individual assumption keeps holding. the types of assumptions sometimes change; we can clarify they valued the assumptions. they give priority to the common assumptions in group and leave the non-common assumption; Assumptions involving implicitly ones become evident by collaborative modelling.

36. Time: 22:25—22:30 (Session 2, Students modelling competency)

Title of the Paper: INVESTIGATING STUDENTS DATA MOVES IN A CITIZEN SCIENCE BASED DATA-RICH MODEL-ELICITING ACTIVITY (online)

Author(s): **Jeffrey Allen McLean**, Corey Edison Brady, Hyunyi Jung, Angeles Dominguez, Aran Glancy

Institution(s) and Country/Region: University of North Carolina at Chapel Hill, United States of America

Short abstract of the paper: Citizen Science provides the means for students to engage in collecting and analysing data important to their local environments. In this study, undergraduate students in the United States participated in a model-eliciting activity to

analyse and make sense of large, complex, and messy data sets gathered in connection with a citizen science project. We focus on the data moves that students performed in order to filter the data into a manageable form. We argue that model-eliciting activities offer entry points to appreciate the complexity of citizen science as a practice and the value of the scientific questions that citizen science projects are engaging. This has merit as providing an 'application context' but also as providing a gateway into participating in citizen science efforts.

37. Time: 22:30—22:35 (Session 2, Students modelling competency)

Title of the Paper: DIFFERENCES IN STUDENTS CONCEPTIONS ABOUT MATHEMATICS WHEN PARTICIPATING IN A MATHEMATICAL MODELING CONTEST (online)

Author(s): **Flavio Guíñez**

Institution(s) and Country/Region: Universidad de Chile, Santiago, Chile

Short abstract of the paper: This study focuses on exploring high-school students conceptions about mathematics when they work autonomously on solving real-world mathematical modeling problems during a team-based contest. Some preliminary results, based on the analysis of auto-reported opinions of two participating teams, suggests that only exposure to this type of modeling tasks triggers certain changes on how they perceive the discipline. According to these findings, students seemed to develop a more complex and precise conception of what mathematics and mathematical work are about. In this ongoing research, we will seek to understand these differences in greater depth, by using a mixed methodology and expanding the sample of students. With this, we hope to contribute to the understanding of the important role that this type of modeling tasks could play in students education.

38. Time: 22:35—22:40 (Session 2, Students modelling competency)

Discussion

39. Time: 22:40—22:45 (Session 2, Students modelling competency)

Title of the Paper: MEASUREMENT MATHEMATICAL MODELING COMPETENCY AND ITS RELATIONSHIP TO MATHEMATICAL INTERESTS OF SEVENTH GRADE (in Shanghai)

Author(s): **Xie Zhiyong**, Li Yaling, Wang Tian, Liu Jian

Institution(s) and Country/Region: Beijing Normal University, Beijing, China

Short abstract of the paper: The study is based on a mathematical modeling process in the National Curriculum Standards and develops a large-scale testing tool for mathematical modeling competency to measure the mathematical modeling competency of seventh-grade students. In addition, the influence of the interest of mathematics learning on mathematics modeling competency is also discussed. The results show that there is no gender difference in the mathematical modeling competency of the seventh-grade students, but there are significant urban-rural differences; With the improvement of mathematical modeling competency, the interest in mathematical learning increases significantly.

40. Time: 22:45—22:50 (Session 2, Students modelling competency)

Title of the Paper: ASSESSMENT OF FOUR-GRADE STUDENTS MATHEMATICAL MODELLING COMPETENCY: TAKE ONE CITY OF CHINA AS AN EXAMPLE (in Shanghai)

Author(s): **Tian Wang**, Xie Zhiyong, Jian Liu

Institution(s) and Country/Region: Beijing Normal University, Beijing, China

Short abstract of the paper: The study explored 298 four-grade Chinese students competency of mathematical modelling and its relationship to their mathematics competency. Descriptive analysis and correlation coefficient were used and reported to

describe the mathematical modeling competency and the sub-competencies of four-grade students and to analyze the relationship between the mathematics competency and the sub-competencies as well as their mathematics competency. Findings indicated that four-grade students competency of mathematical modelling were not proficient. While, among those sub-dimension of mathematical modelling (Simplifying, Mathematising, Working mathematically, Interpreting, Validating), students competency of working mathematically were the best. Besides, strong positive correlation between mathematical modeling competency and mathematics competency ($p < 0.001$) was found in the data collected. The competencies of simplifying, mathematising and working mathematically in students mathematical modelling are more related to their mathematical performance than interpreting and validating.

41. Time: 22:50—23:00 (Session 2, Students modelling competency)

Discussion

Session 3

14:30-16:30 Beijing time, July 17th

42. Time: 14:30—14:35 (Session 3, Students modelling competency)

Title of the Paper: STUDY OF A PROBLEM SOLVING USING THE EXTENDED MATHEMATICAL WORKING SPACE FRAMEWORK (EXTENDED MWS) (online)

Author(s):**Laurent Moutet**

Institution(s) and Country/Region: Paris Diderot University, Paris, France

Short abstract of the paper: The aim is to show the analysis of a problem solving using the theoretical framework of the extended mathematical workspace (Extended MWS) and the Blum and Leiss modeling cycle with a multidisciplinary approach (contribution of physics and mathematics). This problem-solving study the possibility of producing an intense magnetic field using a wire winding for use in a medical imaging device for example. The fields of electromagnetism and calorimetry are used in physics and that of algebra in mathematics. The extended MWS framework makes it possible to analyze academic tasks by considering the relationships between the cognitive plane of students, the epistemological plane of mathematics and that of physics. The whole activity proposed to grade 12 students in France can be described by three successive complete modelling cycles. The articulation of the different planes is studied according to the stage of the modelling cycle.

43. Time: 14:35—14:40 (Session 3, Students modelling competency)

Title of the Paper: MATHEMATICAL MODELLING LEARNING IN INDONESIAN SENIOR HIGH SCHOOL (online or in Shanghai?)

Author(s):**Bambang Riyanto**

Institution(s) and Country/Region: Sriwijaya University, Ogan Komering Ilir, Indonesia

Short abstract of the paper: The aim of this study are, firstly, to produce mathematical modelling using PDAM, online and conventional taxi, car speed on tol road, musi 2 bridge Palembang, tol fee contexts in senior high school that are valid, secondly, to produce mathematical modelling tasks using PDAM, online and conventional taxi, car speed on tol road, musi 2 bridge Palembang, tol fee context that are practical. Research used development research developed by Akker, Gravemeijer, McKenney and Nieveen. Development research consists of 3 stages. The first step, analysis, The second step, design and product. The final step, formative evaluation design, i.e. self-evaluation, one-to-one, expert review, small group, and field tests. The data are analyzed, firstly, walkthrough, analysis based on expert comments to get mathematical modelling tasks which valid, secondly, analyze the results of the review in one to one, small group to gain practicality. Based on expert validation, students' answers, and comment of the student, we obtained the task of modelling using PDAM, online and conventional taxi, car speed on tol road, musi 2 bridge Palembang, tol fee contexts which was valid and practical.

44. Time: 14:40—14:45 (Session 3, Students modelling competency)

Title of the Paper: INTRODUCING A COMPOSITE MODEL FOR INVESTIGATION IN REAL WORLD PROBLEM (online)

Author(s): **Kazem Abdollahpour Chenary, Abolfazl Rafiepour**

Institution(s) and Country/Region: Shahid Bahonar University of Kerman, Iran

Short abstract of the paper: This study deals with the cultural-historical theoretical framework of activity theory. The first generation is known as Vygotsky's triangular model that that it focuses on the action of individual. In the second generation, the focus shifts from action of individual to collective activity and the model of activity system is formed. In the third generation, interaction between two activity systems is proposed. In 2006, Jurdak present the fourth generation of activity theory about Problem solving in three contexts school, simulated real-world and real-world context. Finally, this study presents the fifth generation as composite model by integrating the fourth generation (problem solving activity system) with modelling cycle. So, the composite model is a

suitable tool for analyzing of tensions of real world problems in studies of mathematics education especially mathematical modelling.

45. Time: 14:45—14:55 (Session 3, Students modelling competency)

Discussion

46. Time: 14:55—15:00 (Session 3, Students modelling competency)

Title of the Paper: A COMPUTER-BASED LEARNING ENVIRONMENT ON MATHEMATICAL MODELLING: RESEARCH DESIGN AND PILOT STUDIES (online)

Author(s): **Lena Frenken**

Institution(s) and Country/Region: University of Muenster, Germany

Short abstract of the paper: In the sense of modelling and applications, technology-rich learning environments are believed to be fruitful and positively influencing because they offer several possibilities, for example to present problems in a more realistic way or to use appropriate and authentic tools. Due to those aspects, the project "Modi - Modelling digitally" at the University of Muenster aims to investigate a computer-based learning environment on the one hand and the imparting of metacognitive knowledge of mathematical modelling on the other hand as supportive components during modelling in school. Based on theoretical considerations, a test instrument on metacognitive knowledge, which was analyzed in a first pilot study, was evolved. Furthermore, a second pilot study is planned to investigate the students modelling processes in the digital learning environment. Aim of this contribution is to present those pilot studies and draw conclusions for the main study as well as for improving modelling in school under the usage of digital media.

47. Time: 15:00—15:05 (Session 3, University Students modelling competency)

Title of the Paper: UNDERGRADUATE STUDENTS' MODELLING ROUTES
MEDIATED BY TECHNOLOGY IN THE LEARNING OF LINEAR
TRANSFORMATIONS (online)

Author(s):**Susana Carreira**, Guillermo Enrique Ramirez Montes, Ana Claudia Henriques

Institution(s) and Country/Region: Universidade do Algarve & UIDEF - IE,UL , Faro,
Portugal

Short abstract of the paper: Technology-mediated mathematical modelling has been recognized as a significant learning context. This paper reports on a study aiming to characterize the modelling routes performed by Costa Rican undergraduate students when solving a mathematical modelling task using technological resources as a means to explore the concept of linear transformation. Data collected from audio records of students discussions, their written work, and GeoGebra files show that the group of two students we focus in this paper performed a linear modelling route, by creating a mathematical model with the software, which highlights the visual aspect and the geometric transformation concept.

48. Time: 15:05—15:10 (Session 3, University Students modelling competency)

Discussion

49. Time: 15:10—15:20 (Session 3, University Students modelling competency)

Title of the Paper: IS QUALITY TEACHING FAVOURABLE FOR THE DEVELOPMENT OF MODELLING COMPETENCY? AN EMPIRICAL STUDY WITH ENGINEERING STUDENTS OVER TWO YEARS (online)

Author(s): **Rina Durandt**, Werner Blum, Alfred Lindl

Institution(s) and Country/Region: University of Johannesburg, South Africa

Short abstract of the paper: This paper reports on empirical results concerning the influence of quality teaching on the development of engineering mathematics students modelling competency. An investigation over two consecutive years (2019 & 2020) is meant to yield prospects for engineering mathematics teaching in the future. In 2019, approx. 150 first year engineering students were exposed to a modelling unit (diagnostic test, pre-test, five lessons with ten tasks, and post-test) following two different teaching designs, similar to the German DISUM study, and the same structure, with slight changes in the tasks used, is planned for 2020. One group of participants was offered an independence-oriented teaching style, while two other groups of participants were taught according to a more traditional teacher-guided style. Linear mixed regression models were used to compare pre- and post-test results, considering the entrance test as a covariate. The 2019 results show that all groups had significant learning progress and that the group taught according to the independence-oriented design had the biggest competency growth, particularly for modelling. The 2020 results are still to be evaluated.

50. Time: 15:20—15:30 (Session 3, University Students modelling competency)

Title of the Paper: VALIDATING A MODELLING COMPETENCIES ASSESSMENT
(online)

Author(s): **Jennifer A. Czocher**, Sindura Kandasamy, Elizabeth Roan

Institution(s) and Country/Region: Texas State University, United States of America

Short abstract of the paper: This development and validation study is part of a larger project focused on exploring development of mathematical modeling competencies among STEM undergraduates. We share a new assessment targeting modeling competency that is appropriate for undergraduates in advanced mathematics.

51. Time: 15:30—15:35 (Session 3, University Students modelling competency)

Title of the Paper: MATHEMATICAL MODELLING IN THE TRAINING OF
ENGINEERS IN THE CIVIL STRUCTURES CONTEXT (Presentation not confirmed)

Author(s): **Saul Ernesto Cosmes Aragon**, Elizabeth Montoya Delgadillo

Institution(s) and Country/Region: Pontificia Universidad Catolica de Valparaiso, Chile

Short abstract of the paper: The role of the mathematical modelling competency in the training of engineers is researched. To do this, it is investigated if modelling is presented in the engineer training and how it is treated, to finally identify links that promote dialogues between the various axes of an engineers training. As a theoretical approach, the Extended Mathematical Working Space theory is used for the engineering and modelling cycle of Borromeo Ferri. Specifically with a qualitative methodology under the case study, specifically with the case of the training of Civil Engineering students of a Chilean University. From the results, it is highlighted that the modelling is present in the engineers training, however, this is presented in a fragmented way, on the one hand in the class a modelling that is part of previously structured models is privileged, but the evidence of mathematization process is strongly evidenced. On the other hand in the

elaboration of projects, work with real situations is privileged but the mathematization process is strongly influenced by the use of software.

52. Time: 15:35—15:40 (Session 3, University Students modelling competency)

Discussion

53. Time: 15:40—15:45 (Session 3, University Students modelling competency)

Title of the Paper: MATHEMATICAL MODELLING WITH BIOLOGY
UNDERGRADUATES: USING ACTIVITY THEORY TO UNDERSTAND TENSIONS
(online or in Shanghai?)

Author(s): **Yuriy Rogovchenko**

Institution(s) and Country/Region: University of Agder, Kristiansand, Norway

Short abstract of the paper: Using activity theory framework, we analyze biology undergraduates work on mathematical modelling tasks in extra-curriculum sessions at one of the research-intensive Scandinavian universities. Our analysis reveals several tensions prompting intrinsic contradictions in the mathematics classroom which may be resolved using modelling as a tool in the mathematics education of future biologists.

54. Time: 15:45—15:50 (Session 3, University Students modelling competency)

Title of the Paper: CALCULUS LEARNING COMPETENCY THROUGH MATHEMATICAL MODELLING (online)

Author(s): **Lorenza Illanes, Roberto Retes**

Institution(s) and Country/Region: Tecnológico de Monterrey, México; Universidad Peruana de Ciencias Aplicadas (UPC), Santiago, Chile

Short abstract of the paper: In this research the level performance acquired in Calculus learning was studied by using mathematical modeling to represent problem situations that corresponded to the science field. The research is qualitative with four different samples of students of Engineering and Economic and Administrative Sciences. Various problems of Calculus were designed by Mathematical Modeling and a process of performance evaluation for the educational model based on competencies was done. For each stage of mathematical modeling cycle a taxonomic framework, that distinguishes four levels of thought processes, was investigated in various situations problem. A test to evaluate the performance was done. Several problems at each stage of Mathematical Modeling levels were measured for each student. A group frequency analysis of these levels was made, the results and analysis are presented.

55. Time: 15:50—15:55 (Session 3, University Students modelling competency)

Title of the Paper: APPLICABILITY AND TRANSFERABILITY-IMPORTANT PEDAGOGICAL OBJECTIVES CRUCIAL IN THE COMPARTMENTAL ANALYSIS MODULE OF AN INTRODUCTORY COURSE IN ORDINARY DIFFERENTIAL EQUATIONS (Presentation not confirmed)

Author(s): **John Anthony Gordon**

Institution(s) and Country/Region: City University of New York, United States of America

Short abstract of the paper: Mathematical modeling is a very important component in the compartmental analysis module of an undergraduate introductory course in ordinary differential equations. Within this context, our research has indicated that there are two principal pedagogical objectives that the mathematics educator must make every effort to satisfy applicability of course content to the solution of real-world mathematical problems and transferability of modeling skills across a wide cross-section of scientific disciplines. These two objectives, when met, have been shown to dramatically improve student performance in the course.

56. Time: 15:55—16:00 (Session 3, University Students modelling competency)

Title of the Paper: RESEARCH ON EVALUATION OF COLLEGE STUDENTS' MATHEMATICAL MODELING ABILITY BASED ON AHP AND BP NEURAL NETWORK (in Shanghai)

Author(s): **Yixin Dong**, Huanhuan Zhang, Meng Ci, Ziyi Wang

Institution(s) and Country/Region: Huaibei Normal University, China

Short abstract of the paper: Higher education in our country should stick to the principle of Undergraduate-Oriented and aim to accelerate the construction of high-level undergraduate education. Excellent mathematical modeling literacy is conducive to enhancing students' innovation capability and also the problem-solving ability. The idea of constructing this evaluation model is as follows. Firstly, conducting statistical analysis of various factors affecting college students' mathematical modeling ability through questionnaires. Secondly, constructing four first-level indicators including subsystems according to the survey results, and then forming a three-level evaluation system. Thirdly, determining the weight of each indicator in the evaluation system through the Analytic Hierarchy Process (AHP). Finally, training and testing the BP network by using MATLAB to complete this evaluation model. The model could provide new ideas for the evaluation of college students' mathematical modeling ability.

57. Time: 16:00—16:10 (Session 3, University Students modelling competency)
Discussion

58. Time: 16:10—16:30 (Session 3)

Title of the Paper: FINAL REPORT AND DISCUSSION (online)

Author(s): **Team TSG 22**

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Note:

Class B:

- Session 0 (add.): 14:30-16:30 Beijing time, July 13th
- Session 1: 19:30-21:00 Beijing time, July 13th
- Session 2: 21:30-23:00 Beijing time, July 16th
- Session 3: 14:30-16:30 Beijing time, July 17th