Topic Study Group 45

Mathematics for Non-specialist/Mathematics as a Service Subject at Tertiary Level

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ABSTRACT This contribution describes the themes and programme of the topic study group on mathematics for non-specialist/mathematics as a service subject at ICME-14 and outlines directions of future work.

Keywords: Mathematics for non-specialists; Service mathematics.

1. Working Team, Themes and Questions

The working team for Topic Study Group 45 consisted of the following team members: Burkhard Alpers (Germany, Chair), Mitsuru Kawazoe (Japan, Co-Chair), Marta Caligaris (Argentina), Olov Viirman (Sweden), and Jing Zeng (China). This TSG dealt with the specialties of mathematics as a service subject, i.e. mathematics education provided as service in application study courses. The latter comprise all kinds of study courses in natural sciences, engineering, business and economy where more advanced mathematical terms and models are used but also study courses where mainly statistical methods are applied as in medicine and social sciences. The main educational goal of service mathematics consists of enabling students to understand and use the mathematical concepts, models and procedures as they are needed in their application study courses as well as in later job profiles. Essential questions related to the didactics of service mathematics are:

- Which understanding and competencies are needed in application subjects (like mechanics, national economics, experimental pedagogic) in order to understand the terms and development of models and to work on tasks successfully? How can this information be used to specify a curriculum for a specific study course? By which suitable learning arrangements (e.g. application problems and projects) can such competencies be acquired by students?
- How can mathematics be made relevant for students in application study courses such that students experience mathematics education as integral part of their study course and are thus motivated to undertake the necessary efforts?

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- What are the mathematical transition problems when students enter university in an application study course and what are suitable measures to overcome them?
- What is the influence and role of technology in service mathematics courses? How does the existence of technology embodying mathematical concepts and procedures change the goals of mathematics and the ways of teaching and learning?
- Who teaches service mathematics and how do different backgrounds influence the teaching practices? What are suitable boundary conditions for successful teaching?
- What are promising research designs in service mathematics and how can different roles be integrated: mathematician, mathematics educator, application specialist?

Some of these questions were tackled in the paper and poster contributions to this TSG which will be outlined in the next section.

2. Program Overview

The topic study group's programme consisted of three sessions for paper presentations as well as a small part of the overall poster session. Because of the worldwide Covid-19 pandemic, most participants attended online via a video conferencing system which worked quite well for presentation and discussion. In the video meetings about 14–18 participants attended and there was a lively discussion on topics addressed in the presentations.

The following papers (Tab. 1) were accepted for the conference all of which except for the one by Lehmann[6] were presented at the paper sessions:

Tab. 1. List of papers presented

Paper and author(s)	
[1]	Mathematics as a service subject: historical development and major players from a European perspective. ***Burkhard Alpers*** (Germany).
[2]	A practice report on mathematical modelling education for humanities and social sciences students. ***Mitsuru Kawazoe*** (Japan).
[3]	Flexible content, instruction, and assessment in a university-level quantitative reasoning course. ***Deependra Budhathoki****, Gregory D. Foley, and Stephen N. Shadik* (USA).
[4]	A small-scale implementation of inquiry-based teaching in a single-variable calculus course for first-year engineering students. ***Olov Viirman*** *and Irina Pettersson* (Sweden).
[5]	Sometimes mathematics is different in electrical engineering. ***Jana Peters*** *and Reinhard Hochmuth* (Germany).
[6]	Which mathematics competences are relevant for engineering education? — a mixed methods study. ***Malte Lehmann*** (Germany).
[7]	The attitudes of lecturers and students towards puzzle-based learning: the case of differential equations. ***Farzad Radmehr*** (Norway/Iran), *Faezeh Rezvanifard* (Iran), *and Michael Drake* (New Zealand).
[8]	Can we make mathematics interesting for engineering students? modelling tasks in an ordinary differential equations course. ***Svitlana Rogovchenko*** (Norway).
[9]	Teaching materials on calculus as seen from application to engineering. ***Satoru Takagi****, Kesayoshi Hadano, and Sei-ichi Yamaguchi* (Japan).

The paper by Alpers[1] served to set the scene by giving a historical overview of the development of didactical thinking about the provision of service mathematics. Particularly during the last two decades the topic received more and more attention in research and in communities of practitioners but the area is still under-researched and many open questions need to be investigated. The other papers dealt with mathematics education for non-mathematics majors in different types of study courses. Only Kawazoe[2] and Budhathoki et al.[3] were concerned with mathematics education in a non-engineering study course whereas the other papers investigated aspects of mathematics teaching in engineering where mathematics is well acknowledged as being a fundamental subject. Kawazoe[2] described a concept for making mathematics education more relevant for students of social sciences and psychology where students perform modelling activities in groups. Since the concept has been in use for about a decade, long-term experience and necessary modifications could be reported. The paper by Budhathoki et al.[3] described an entry-level course on quantitative reasoning for non-STEM majors where students were given many opportunities for collaboration in problem solving. Since the course content was not fixed, the instructor could flexibly react to students' needs. The students who had rather negative prior experience reacted positively to this form of education.

The remaining papers were all related to teaching mathematics in engineering study courses. Viirman and Pettersson[4] described a small-scale implementation of inquiry-based teaching in a first-year calculus course where students investigated application problems in group sessions. Since this involved the meaningful usage of concurrently learnt mathematical concepts, students gained a better and deeper understanding of those concepts. The authors used commognitive theory as a framework for their research. Peters and Hochmuth[5] addressed differences in mathematical practices between the usage of mathematics in application subjects and the development of theory in the proper mathematics education classes. They used the Anthropological Theory of Didactics as a theoretical framework for their analysis and made suggestions for dealing with students' problems resulting from the differences. Lehmann[6] investigated how first-year engineering students solved physics problems using the theoretical concept of epistemic games for analysis. He found out that higher mathematical content knowledge was a good predictor for success in physical problem solving. Moreover, the students' problem solving behaviour developed more into the direction of schematic work ("recursive plug and chug game") where they tried to use a well-known schematic algorithm for problem solving which he related to the schematic use of mathematics in their mathematics education.

The next two papers[7,8] addressed the problem of making differential equation courses more relevant and interesting for engineering students. Radmehr et al.[7] investigated the effects of puzzle-based learning on the attitudes of lecturers and students where a puzzle is a non-standard, open question with an entertaining component. Based on a questionnaire and interviews the authors found out that a majority of students enjoyed working on this kind of problems and thought that this work improved their understanding and ability to solve realistic problems.

Rogovchenko[8] tried to make mathematics more relevant to engineering students by introducing assessed modelling tasks in a differential equations course. Using the framework of activity theory, she found some contradictions between teachers' and students' goals where teachers strived for deeper understanding whereas students were predominantly interested in getting better grades. Conflicts between students occurred due to different backgrounds, work preferences and mathematical skills. Finally, Takagi et al.[9] developed teaching materials on calculus where they started with an application which made the subsequent concept relevant to the students and enabled them to attach practical meaning to those concepts. They illustrated their approach by providing example applications for introducing partial derivatives and double integrals.

The following posters (Tab. 2) were presented at the poster session.

Tab. 2. List of posters presented

Poster and author(s)	
[10]	Peer-assisted learning in less structured courses: a case study in a first-year course on mathematical modelling. ***William Man Yin Cheung*** (Hong Kong SAR, China).
[11]	Implementation of projects about scheduled in software r in a linear algebra course for students of business computing career at the University of Costa Rica. ***Luis Eduardo Amaya*** (Costa Rica).
[12]	On the mathematical knowledge, skills and related information technology needed to pave the way for students' career development. ***Jiao Liu*** (China).

Cheung's poster[10] investigated the effect of peer-assisted learning on increasing the interest and "sense of belonging" of non-mathematics majors in a course on mathematical modelling. The poster by Amaya[11] was concerned with using the statistics programming language R to get business computing students more interested in linear algebra topics, and Liu's poster[12] described her ongoing work on adapting the mathematics teaching of vocational students to their real needs using spreadsheet technology.

3. Future Directions and Suggestions

A more comprehensive overview of the state of the art in the didactics of service mathematics can be found in the report (Alpers, 2020) which shows that research on this topic has gained considerable momentum. Yet, as can be seen by comparing the questions stated in the first section with the results of TSG-45 presented in the second one, there are still many areas worth further investigation. Since there are many application study courses with special needs and requirements, there is still a plethora of research questions to be tackled in the decades to come.

References

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