TSG 7: Mathematics education in and for work

Team Chairs: ***Henk van der Kooij***, The Freudenthal Institute, Utrecht, The Netherlands
Rudolf Strässer, University of Giessen, Germany
Team Members: ***Susan Forman***, City University of New York, Bronx, USA
Jim Ridgway, University of Durham, United Kingdom
Robyn Zevenbergen, Griffith University, Bundall, Australia

Aims and focus

The focus of this topic study group was to identify general characteristics of the nature of mathematics as it appears in or is needed for work, seen from the perspective of occupational standards ('broad occupational competences' versus 'highly occupation-specific skills', problem-solving skills, flexibility and quality, transfer) and the influences of Information and Communication Technology (artefacts, simulation, spreadsheets, data).

The second focus of the topic study group was to look into characteristics of the teaching and learning of mathematics at work, in classrooms and other settings, if teaching and learning are oriented to preparing students for work-place related situations. Those characteristics can be approached from the perspective of pedagogy (situated learning, situated abstraction, authentic learning) and quantitative literacy (mathematical literacy, overarching concepts (PISA), mathematics in context).

The overall aim of the TSG was to discus consequences of the above-mentioned characteristics for the nature of mathematics and mathematics education in and for work. Three sessions were organised on sub-themes and the final session was used for discussion. Even if the third session was planned to be on the use of modern technology related to workplace mathematics, this issue naturally came up also in the first two sessions. As a consequence, and reflecting the presentations and discussion in sessions 1 to 3, there is no specific report on workplace related use of technology.

Characteristics of mathematics for work

Quantitative literacy: An introduction
Henk van der Kooij, The Netherlands
"The contrast between mathematics in school and mathematics at work is striking. Mathematics in the workplace makes sophisticated use of elementary mathematics rather than, as in the classroom, elementary use of sophisticated mathematics. Work-related mathematics is rich in data, interspersed with conjecture, dependent on technology, and tied to useful applications. Work contexts often require multi-step solutions to open-ended problems, a high degree of accuracy, and proper regard for required tolerances. None of these features are found in typical classroom exercises." (Steen, 2001). Two statements for discussion were presented:

- The discipline itself should not define the mathematics program in vocational courses. Rather: the context of work should define the desirable mathematical activities.
- Abstraction and formalism should not be goals for mathematics education for the workplace; situated abstraction and 'mathematics in context' should.

Introduction on ambivalence of technology
Rudolf Strässer, Germany
A competent worker in a technology-rich environment should be in control of his workplace, should understand, not only handle, his instruments and should know about the mathematical models in use. Technology is hiding mathematics from the perception of its user (black box). In a technology-rich environment, mathematics becomes visible only in breakdown situations, when technology stops to function properly. But technology can also serve as a means to understand – helping to open – the 'black box', by simulations and 'what-if'-exploration.

Abstraction in workplace expertise
Celia Hoyles and *Richard Noss*, United Kingdom
Two studies – one with nurses in a paediatric hospital and the other (ongoing) in large manufacturing businesses – were presented. The findings from the first studies suggest that rather than being a set of disparate skills, mathematics used at work takes the form of well-connected situated abstractions, where abstraction is expressed by means of the tools and artefacts of the practice and relies on shared workplace knowledge and discourse. The latest research on 'techno-mathematical literacies', as used in computationally-rich modern workplaces, was presented too. "… the mathematical models involved appear different than conventionally-understood". They are "not mediated by formal mathematical symbol systems and artefacts, but by 'situated' techno-mathematical artefacts" (quote from the presentation in the Topic Study Group).

The numeracies of boat building
Robyn Zevenbergen and *Kelly Zevenbergen*, Australia
A case study of young boat builders was presented. What this case study has illustrated is that young people often approach the numeracy demands of their work in ways that are different from those of older staff. Their approaches tend to rely more on estimation, problem solving, holistic thinking and intuitive methods. As such, the study should not be interpreted to mean that young people do not have number skills. Rather, it suggests that the other skills take a higher priority in their approaches to working mathematically.

Mathematics at the workplace – the perspective of pedagogy

Mathematical knowledge of workers at South-African Cultural Villages
Mogege Mosimege, South Africa
Two studies of the making of artefacts in Cultural Villages were presented. Cultural villages are specifically created places to preserve the national heritage of pre-colonial South Africa from disappearance in a more and more global economy. A mathematical analysis of the various artefacts and activities at the villages provide an opportunity to explore the mathematical concepts that are used regularly by inhabitants (workers) at such villages. Mathematics is a useful subject for every one, it is both relevant and practical and is applicable to everyday life. Educators can help to close the gap between classroom activities and activities outside the classroom, ensuring that mathematical concepts learned in classrooms are not dealt with in isolation but take into account daily experiences of workers in various settings, including Cultural Villages.

Mathematics in Italian vocational schools

Brunetto Piochi and *Rosa Laura Ancona*, Italy

The case of a Vocational School for Tourism Operators was presented. Vocational schools in Italy operate on the basis of specific final "vocational profiles", which can be used as reference to identify the basic abilities required to transfer and use mathematical learning in the context of work-related projects. The teaching staff includes teachers specialized in the various vocational disciplines. It has therefore been possible to activate an analysis for some specializations, starting from the study of the vocational profile itself, to identify the mathematical knowledge and skills and to devise suitable activities bringing them to the forefront.

Constructing mathematical concepts. The effects of a writing workshop based on learner's own experience

Corinne Hahn, France

Students' practices in mathematics differ depending on whether they are solving a problem in class, or in a situation outside the classroom. They often have difficulties connecting school mathematics and out-of-school mathematics, which is a major problem in vocational education where students should be able to link professional experience to theory.

After presenting the conceptual framework, a system was discussed that is devised and experienced with sales managers-to-be in order to help them to connect knowledge learnt at school with business practices.

Mathematics needs of students in emerging technologies

Mary Ann and *Robert Hovis*, USA

The outcomes of CRAFTY-workshops, part of a bigger project, were presented. CRAFTY (Curriculum Renewal Across the First Two Years) brought together mathematics teachers, technical faculty people and people from industry. Most technical faculty believe that content should be addressed in ways that demonstrate connections between mathematics and other areas, as well as among mathematics topics. Students must be able to transfer the mathematics knowledge or skills to applications within their disciplines. Focusing on local businesses gives immediate relevancy to applications.

Mathematics faculty must help provide students with a variety of habits (soft skills) that will enable them to succeed in the workplace. The skills that employers want from their employees rarely include specific content. They want instructors to strengthen the student's ability to think, to communicate, and to be responsible.

A perspective on numeracy

Steve Thornton and John *Hogan*, Australia.

Numeracy certainly means more than having competence with a set of basic mathematical skills. This has serious implications for all teachers who are preparing young people for life, learning and the workplace. A Numeracy Framework was presented as a way of describing numeracy, diagnosing learning issues, supporting teachers' planning for teaching to students and workers so that they can choose to learn how to act numerately. Some practical ways of adopting this framework for use by teachers were briefly outlined.

Discussion

Based on the issues raised in the first three sessions, the final session was devoted to discussing some key questions about mathematics for work.

What is mathematics for/in the workplace?

It seems that a lot of discussion is focused on the question "can we call this mathematics or is it just general knowledge?" Why not just "coping with the quantitative/qualitative aspects of the reality (of the workplace) around us". Or should such aspects be incorporated in the definition of mathematical thinking and acting?

Given all the research that ends in "school mathematics and workplace needs don't fit together", what should a vocational mathematics program look like? What are the key issues to consider? (Steen, Hovis)

What about technology: What are 'appropriate uses'?

We need more insight into what technologies are important (use of spreadsheets, statistical quality control software). How deeply should these be understood so as to be manageable? We need more research on techno-mathematical literacy.

How about transfer?

One vision: Transfer to new situations is only possible after generalizing from the context-bound concrete problem situations and then apply the generalized knowledge to new situations.

This is the approach most often used in education. But the results are mainly very disappointing.

Another vision: Find a set of contextual and meaningful contexts which are not "too far apart".

Identify a structured situated abstraction. Will that enhance transfer to other contexts and situations? Not so much is known yet regarding this issue.

What status does research in vocational education have in the mathematics education research community?

Unfortunately the answer to this question is: hardly any.

References

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This report has been written by Henk van der Kooij and Rudolf Strässer with support from the team members. They are happy to be contacted at their respective institutions for further information on the work of this TSG.