# Mathematics-in-Industry Study Groups in Australia, New Zealand and Japan

**Winston L. Sweatman**

School of Natural and Computational Sciences, Massey University
Private Bag 102904, North Shore, Auckland 0745, New Zealand

e-mail: w.sweatman@massey.ac.nz

## 1 Introduction

Mathematics-in-industry study groups play an important role in linking science with industry in the Asia-Pacific region. I have had the good fortune to have been able to attend several such workshops, including nearly every occurrence of the Australian and New Zealand mathematics-in-industry study groups (MISG and MINZ) since 2004. The Australian and New Zealand study groups are the subject of Section 2.

In 2016, there was a very enjoyable exchange between the established mathematics-in-industry study groups in New Zealand and Japan. This exciting joint venture is the subject of Section 3.

## 2 Mathematics-in-Industry Study Groups in Australia and New Zealand

The annual Mathematics-in-Industry Study Groups (MISG) in Australia began in 1984. My first experience was in 2004 when the meeting moved to New Zealand. It was hosted by Massey University, Auckland for three years. Subsequently, in 2007, MISG returned to Australia and was successively hosted, for three-year periods, by the University of Wollongong, RMIT University, Queensland University of Technology and the University of South Australia. The last of these hosted the event for four years. The 2020 MISG will be hosted by the University of Newcastle.

In addition to MISG in the Australian summer, a second study group is now held in the New Zealand winter. The New Zealand study groups have been coordinated nationally through Mathematics-in-Industry New Zealand (MINZ), with administrative support by KiwiNet, a New Zealand-wide network.

The MINZ series began in 2015 and has been held every year since. The host institution has changed every year. To date the MINZ study group has been hosted by Massey University in Auckland, Victoria University of Wellington, Massey University in Palmerston North, Auckland University of Technology and the University of Auckland. In 2020, the meeting will go to the South Island and be held at the University of Canterbury.

The study groups, MISG and MINZ, function as a special interest group of the Australia and New Zealand Industrial and Applied Mathematics (ANZIAM) society, with MINZ also reporting specifically to the New Zealand branch of the ANZIAM society.

## 2.1 The MISG Structure

The study groups, MISG and MINZ, are each one week long and broadly follow the 'standard model' of study group as described by the European Study Group Handbook [1]. They usually run Monday to Friday, but sometimes run Tuesday to Saturday to fit around Monday public holidays. Typically, 4 to 7 projects are brought to the study group by industry partners. The industry representatives are available for the whole week to assist with teams working on their project.

One distinctive feature of MISG and MINZ is the presence of moderators. Within each project group there are typically two moderators (sometimes three), and often a student moderator as well. The moderators are mathematical researchers brought to the study group to lead a project, taking responsibility for its coordination and reporting.

Student moderators were introduced at Auckland in 2005 as reported in the MISG proceedings of that year: *"A new successful innovation was to assign a postgraduate student moderator for on-line experience. All responded well."* [2]. Subsequently, student moderators have been a feature of all of the New Zealand study groups and many of the Australian ones too.

With support from the mathematical community, student participation in general has increased over the years. As with other types of participants, having a number of students who have previously participated in a study group has been very helpful.

As well as reporting by presentation during the MISG and MINZ, a key feature of these study groups are the written reports produced following the event. There is a brief, approximately two-page, equation-free report produced a month after the event. These equation-free reports can be useful when promoting the study groups in future years.

Later, a more detailed final report is produced. This report takes the form of a reviewed research paper. These papers provide a valuable record of what was done during the week. In future years, perhaps working with the same industry partner, the information and models contained in the reports are often useful in the context of a new project. The earlier final report papers were contained in annual printed proceedings [3]-[8]. Since 2010, both MISG and MINZ final report papers have been published in the electronic edition of the ANZIAM journal [9]-[17].

## 2.2 MISG Projects

My first MISG project concerned a barn for raising chickens [3]. As a new participant it took a while for me to come to grips with what we were trying to do! As is common for MISG projects, we began by finding out as much as we could about what was involved, looking at data and quantifying measurements, before building a mathematical model.

The projects I have worked on since have been quite varied, as has been the mathematical approaches involved. My first decade in MISG, included projects from industries related to agriculture, electricity, steel and food [18]. Some of the industry partners have returned to the study groups on multiple occasions. In particular, Transpower, whose electricity projects I

worked on in 2007 and 2012 [6, 11], and New Zealand Steel/Bluescope Steel [19, 7, 8, 10, 16] have been regular attendees.

Fonterra, New Zealand, became a regular participant more recently, first at MISG and then at MINZ. They have brought projects relating to the production of dairy produce every year since 2011. I moderated their projects in 2013 and 2018. The 2013 Fonterra project concerned modelling the ripening of cheese [12, 20]. The study group constructed mathematical models of the evolution of sugars, protein and fat with time. The 2018 Fonterra project sought to better understand how mechanical measurements of dairy produce can be related to sensory texture perception. Group work included analysis of industry data as well as study of the physics of tribology.

The two projects I worked on at the University of South Australia both concerned optimisation processes. The 2016 project considered how knowledge of the uncertainty in geological estimates could be used to determine mining sequences [16]. The approaches for this included exploring sample data, constructing physically possible mining sequences, simulating the assembling of ore to meet an order, formulating a mixed integer program and considering a general heuristic strategy. The 2018 project was about optimising carcase cuts in the red meat industry. It was brought by the Australian Lamb company and had four industry experts present for the whole week. In this project, mixed integer programs were both constructed and run to produce optimal solutions.

# 3 Twinned Study Groups: New Zealand and Japan, 2016

Japan launched its own mathematics-in-industry study group in 2010, and this has been run every subsequent year. In 2016, in an exciting new move, the Japanese study group was linked by an exchange visit, to be joint with the New Zealand study group. This was funded by the Royal Society of New Zealand and the Japanese Society for the Promotion of Science Joint Workshop Programme that was awarded to Graeme Wake, of Massey University, and Yasuhide Fukumoto, of Kyushu University.

At the start of July, a team from Japan participated in the New Zealand study group in Wellington. Three weeks later, a team from New Zealand participated in the Japanese study group in Fukuoka and Tokyo. The New Zealand exchange team consisted of one industry representative, four members of academic staff at New Zealand universities, and one student. The Japanese exchange team had a similar composition. Both study groups produced project reports following the event [21, 22].

The New Zealand and Japanese study groups each addressed six projects from six different industry partners. However, two industry partners, Transpower from New Zealand and JAMSTEC from Japan, participated in both study groups with linked projects. Other industry partners in Wellington were New Zealand Steel, and the food/agriculture related companies Compac, Fonterra, and Zespri. All of the New Zealand industry partners had participated previously apart from Zespri. Zespri went on to participate again in a later MINZ study group. In Japan, the other industry partners were $I^2$CNER, Murata Manufacturing, Nippon Steel and Sumitomo Metal Corporation, and Abeam Consulting. Some of these were also repeat participants: Nippon Steel and Sumitomo Metal Company had contributed a project to every previous year of the Japanese study group (cf. [17]).

At the Japanese study group, some of the studies for the Transpower project were continued from the point that had been reached in New Zealand. However, there were also new

Figure 1: In Japan, at the classroom and exploring outside, the New Zealand exchange team: Winston Sweatman, Luke Fullard, Barry McDonald (all Massey University), Steve Taylor (University of Auckland), Alex Van Brunt (Kyoto University), Tim Crownshaw (Transpower). Photographs copyright the author.

investigations of different aspects of the project, and additionally the use of alternative approaches. The JAMSTEC project was quite parallel in nature and varied models were built in both countries.

## 3.1 Steel in New Zealand and Rock in Japan

Projects from the steel industry have been a regular feature of Australian, New Zealand, and Japanese Study groups [17, 19]. There were steel industry projects at both of the twinned New Zealand and Japanese study groups. In Wellington, I worked on the project from New Zealand Steel [17]. This project sought a better understanding of the late stages of steel production where sheets of steel pass through rollers in order to achieve the appropriate gauge or thickness. The process is complicated by various factors. The temperature of the steel, both that being processed and that in the rollers, influences the process. Wear and tear on the active surfaces of the rollers will also have an effect, the most active parts require replacement at half-day intervals. The strategies adopted at the study group included physical mathematical models and statistical analysis of data provided by the industry.

I was joined on the Wellington steel project by my colleague Yasuhide Fukumoto from Kyushu University and member of the Japanese exchange team. We were also to work on the same project when I was a part of the New Zealand team in Japan.

In Japan, I participated in the project brought by $I^2$CNER of Kyushu University [23]. This involved the study of heterogenous rock pore structures, whose permeability is important for a range of applications such as oil and gas production, carbon capture and storage

and geothermal power. Within this project New Zealand team members, Steve Taylor of University of Auckland and myself, focused on toy models of rock structures. These models were constructed from impermeable spheres of two different sizes arranged at the centres and corners of a cubic lattice. As we varied the radii of the two kinds of sphere, we investigated how the porosity, surface area and permeability of the structure changed.

### 3.2 Being a visiting team member

At both events, participants, including the exchange team, were dispersed through different projects. Two members of the New Zealand exchange team focused primarily on the Transpower project in both countries. In Japan, there were also two of us on the $I^2$CNER project, one primarily on the Abeam project and one moving between three different projects.

The New Zealand exchange team in Japan stayed in accomodation close together and travelled as a group. This gave us opportunities for more general discussion of the projects, in the evenings and while travelling.

The Japanese study group differed from the New Zealand one, in that it included a weekend break in the middle with a thousand kilometre change of venue. We enjoyed the memorable six-hour shinkansen train journey from Fukuoka to Tokyo, and the chance to see more of Japan.

## 4 Concluding Comments

The study groups I have participated in have been consistently enjoyable and instructive. This was especially true of the New Zealand-Japanese exchange that provided a wonderful opportunity to learn from one another. We greatly appreciated the opportunities to experience Japan and Japanese culture and have fond memories of our visit.

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