International Mathematical Modeling Challenge (IM²C)[1]

Background

IM²C began in 2015. Its purpose is to provide a vehicle for promotion of mathematical modelling and applications at all levels for all students.

IM²C is a team-based competition. Teams comprise up to four students from the same school, and a team advisor (usually one of their mathematics teachers). They have up to five consecutive days to work on a centrally set modelling task, write a report, and submit it for evaluation.

Australia and the IM²C

Australia's participation in the IM²C has been led and overseen by the Australian Council for Educational Research (ACER), with the support of a volunteer national advisory group of experts in mathematics, mathematical modelling, and leaders in mathematics education to oversee, guide and promote the introduction of IM²C.

Australia first participated in 2016, with 25 registered team. Reports were finally submitted by 15 teams of (mostly) students in Years 10, 11 and 12. Australia's two international entries were highly successful, with both gaining the second highest international award, for 'meritorious achievement'.

In 2017, interest and engagement in the Challenge expanded three-fold. There were 45 submissions; three schools received awards from the Australian judges, with the two best forwarded to the international judging.

Over 320 schools have now made direct contact and expressed interest through the Australian IM²C website. This represents nearly 10% of all secondary schools in just two years. The following tables outline the involvement in the 2017 IM²C.

	Team Registrations				Team Submissions			
State	**Gov**	**Ind**	**Cath**	**Total**	**Gov**	**Ind**	**Cath**	**Total**
ACT	2			2	2			2
NSW	3	3	3	9	3	1	3	7
QLD	1	5	2	8		4	1	5
VIC	25	21		46	13	11		24
WA	12	5		17	7			7
Total	**43**	**34**	**5**	**82**	**25**	**16**	**4**	**45**

Table 1 – Teams

	From registered teams		From submitting teams	
Girls	120	38.8%	72	42.6%
Boys	189	61.2%	97	57.4%
Year 12	63	20.4%	24	14.2%
Year 11	67	21.7%	52	30.8%
Year 10	78	25.2%	42	24.9%
Year 9	57	18.4%	22	13.0%
Year 8	21	6.8%	6	3.6%
Year 7	23	7.4%	23	13.6%
	309		169	

Table 2 – Students

The IM²C problems

In 2016, the IM²C problem was based on the notion of insuring against risk, in the context of an organisation planning an athletics competition, and considering the best way to cover potential

[1] A longer version of this paper is available.

liabilities should the organisation offer a financial performance incentive to athletes who compete and break a world record.

The modelling problem used in the IM^{2}C in 2017 was about the phenomenon known as 'jet lag'. Teams were asked to develop an algorithm that could be used by meeting organisers to decide where in the world would be a suitable location to hold a three-day international meeting of participants from around the world, in order to minimise jet lag and maximise the productivity of the participants. The detailed problem statement criteria used to evaluate responses are at Attachment 1.

Some initial impressions

The following comments are derived from a range of sources including surveys of team advisers (teachers) and direct contact with those whose students participated in both 2016 and 2017.

- The Jet Lag problem was accessible to students of various ages
- Teams used various combinations of mathematics class time, other available school time and weekends to work on the Challenge
- They reported mostly spending up to 20 hours; with most less than 10 and none over 40 hours
- Students appreciated it when their adviser supported them through such things as booking a meeting room and providing 'treats' (coffee, chocolates etc.)
- Electronic sharing of work proved effective for many teams (e.g. Google Docs)

Several factors were identified as causes of teams not submitting, including unsupportive in-school arrangements, students being overwhelmed by other school-related activities at the same time and when students lacked awareness of the modelling process.

In summary, it seems clear that participation is assisted when there has been appropriate advance planning, when other staff are aware of the challenge, and when school processes are established to provide at least some level of support. Participation is severely hampered when these facilitating conditions to not exist.

Summary

The IM^{2}C aims to encourage and facilitate change in some of the classroom practices of mathematics teachers and learners. Mathematical modelling is increasingly recognised as an important way to view mathematical activity, and is undoubtedly a key feature of integrated learning in STEM.

The fledgling Australian engagement with the IM^{2}C is already capturing the imagination and commitment of teachers and students, and this is set to continue to grow in the next few years. Those involved have already produced a range of support materials that help develop knowledge about modelling and specific modelling skills. Promotion and engagement are among current priorities, along with securing the sustainability of an initiative that has great potential to improve the mathematics and STEM experiences and achievement of our young people.

For more go to:

https://www.immchallenge.org.au/

Attachment 1 – Jet Lag problem statement and criteria

The problem for the 2017 Challenge was stated in the following terms:

Problem: Jet Lag

Organizing international meetings is not easy in many ways, including the problem that some of the participants may experience the effects of jet lag after recent travel from their home country to the meeting location which may be in a different time zone, or in a different climate and time of year, and so on. All these things may dramatically affect the productivity of the meeting.

The International Meeting Management Corporation (IMMC) has asked your expert group (your team) to help solve the problem by creating an algorithm that suggests the best place(s) to hold a meeting given the number of participants, their home cities, approximate dates of the meeting and other information that the meeting management company may request from its clients.

The participants are usually from all corners of the Earth, and the business or scientific meeting implies doing hard intellectual team work for three intensive days, with the participants contributing approximately equally to the end result. Assume that there are no visa problems or political limitations, and so any country or city can be a potential meeting location.

The output of the algorithm should be a list of recommended places (regions, zones, or specific cities) that maximize the overall productivity of the meeting. The questions of costs are not of primary importance, but the IMMC, just as any other company, has a limited budget. So the costs may be considered as a secondary criterion. And the IMMC definitely cannot afford bringing the participants in a week before the meeting to acclimatize or give them the time to rest after a long exhausting journey.

Test your algorithm at least on the two following datasets:

Scenario 1) "Small Meeting":	**Scenario 2) "Big meeting":**
Time: mid-June Participants: 6 individuals from: • Monterey CA, USA • Zutphen, Netherlands • Melbourne, Australia • Shanghai, China • Hong Kong (SAR), China • Moscow, Russia	Time: January Participants: 11 individuals from: • Boston MA, USA (2 people) • Singapore • Beijing, China • Hong Kong (SAR), China (2 people) • Moscow, Russia • Utrecht, Netherlands • Warsaw, Poland • Copenhagen, Denmark • Melbourne, Australia

Your submission should consist of a 1 page Summary Sheet and your solution cannot exceed 20 pages for a maximum of 21 pages. (The appendices and references should appear at the end of the paper and do not count toward the 20 page limit.)

The criteria used to evaluate the Australian team reports are :

1. **Problem definition**
   - Identify a real world problem to be solved, and specify precise mathematical questions from the general problem statement
2. **Model formulation**
   - Identify assumptions with justification
   - Choice of variables
   - Identify and gather relevant (needed) data

- Choice and justification of parameter values
- Development of mathematical representations

3. **Mathematical processing**
   - Application of relevant mathematics
   - Invocation and use of appropriate technology
   - Checking of mathematical outcomes for procedural accuracy
   - Interpretation of outcomes in terms of the problem situation
4. **Model evaluation**
   - Explore adequacy and relevance of findings in relation to problem situation
   - Provide further elaboration or refinement of problem
   - Relevance of revised solution(s) following revisiting and further work within earlier criteria
   - Evaluation of sensitivity of solution to changed assumptions or conditions
   - Quality of answers to specific questions posed in problem statement
5. **Report quality**
   - Summary page quality: succinctness, power to attract reader
   - Overall organisation of the report: fitness for purpose, and logical presentation that includes (as appropriate):
     - *Description of* the real-world problem being addressed.
     - *Specification of* the mathematical questions
     - *Listing of* all assumptions *wherever* they are made
     - *Indication of* how numerical parameter values used in calculations were decided on
     - *Setting out of* all mathematical working: graphs, tables; technology output etc
     - *Interpreting* the meaning of mathematical results in terms of the real world problem
     - *Evaluating* the solution(s) in terms of the problem requirements.