IM^{2}C 2023 Australian Judges' Commentary

The Australian IM^{2}C judges congratulate the 56 teams from 18 schools all across Australia who participated in the 2023 International Mathematical Modeling Challenge. Two teams, *Team Onyion* from Brisbane Boys' College and *Calcaholics* from Sydney Boys High School, have entered the international round.

The 2023 Challenge – Using Land: A valuable resource

The main challenge this year was to produce a quantitative decision metric to determine the 'best use' of a parcel of rural land with an area of 3 square km near Syracuse, NY, for local community leaders and business planners. The teams were supplied with some limited geographic statistics, maps and a set of eight suggested land use options. The short- and long-term costs and benefits of at least two of these options were to be modelled mathematically to produce the metric.

Extensions to the main challenge were to re-evaluate the options identified by the metric if a large semiconductor fabrication facility were to be built nearby, and to discuss how the model would need to be changed if the land were in a different location or country.

The written components of the challenge included a summary, a letter to the decision makers, a 20-page report and optional appendices.

Interpreting the problem

This open-ended challenge allowed various interpretations and approaches to be explored. Participants were faced with some interesting decisions:

- How to combine the numerical economic part of the metric with non-numerical community values and preferences?
- How should the economics, community values and preferences be measured?
- What generally applicable economic data should be collected, where can this data be found, and whether to calculate the costs and profits or to compare data from similar companies in the same region?
- What kind of community/environmental factors should be considered, and how to rate them?
- How to use the geographical data, how much of the land to develop, and whether to combine land use options or not?
- How to interpret 'short-term' and 'long-term', and how the land usage varies with daylight hours and seasons?
- And how to justify who should benefit, and who should determine the preferences?

Creating models and solving the problem

Teams chose many different ways of interpreting the problem and implementing the items listed above, but most used simple rating scales of various kinds, combined with various amounts of arithmetic. There were some models of land characteristics, climate change, daylight hours, solar panel efficiency, population change and tourism that were integrated into decision metrics to various degrees. The best reports were the ones that communicated the decisions, methods and results most effectively and convincingly, demonstrating logical, systematic and organized thinking in a neat, easy to understand presentation.

Good reports used as few arbitrary parameters as possible. They used data from relevant sources, with a brief motivation and description of the context, a citation in the text and a corresponding reference in the appendix.

There were some highly sophisticated models, but these tended to over-complicate the problem and often contained errors or misinterpretations. In many cases, these models were less likely to represent well future data such as the semiconductor facility or changing the location. Simpler models, even less elegant piecewise linear constructions, tended to be more understandable, more convincing, and probably closer to the truth than complex models derived from limited data.

Almost all teams imposed their own preferences about the relative importance of relevant factors in the models, but one team allowed users to choose their own preferences before generating results.

Checking and interpreting the results

Many teams this year should be commended for doing some form of sensitivity analysis. Most of these showed how ratings change when one factor is varied. This is a good starting point, and well-suited for studying the effects of single factors but, in a multi-factorial problem such as this, it may have been better to use a spread (distribution) of reasonable values for each independent factor, and then take random samples of all factors to generate a spread of possible results.

Showing the variations in both the input data and the output data visually or graphically greatly helps the readers to understand the reliability of the process.

Alternatively, some teams used hypothetical example data to demonstrate how (parts of) their metric worked.

Completeness

Although it was not necessary to complete all parts of the challenge, teams should obviously endeavour to complete the revisions of the model for the semiconductor facility and/or change of location. Time management was crucial in this year's problem. Planning, allocating tasks and managing time during the challenge are very important. Participants should be aware of how much writing, checking and editing is required and how much time this process can consume.

Finally

We congratulate all participating teams on their efforts during this challenge, we thank each school for their support and we hope every team member will continue to improve their skills in thinking and communicating mathematically. The originality of the models developed was inspiring, and we look forward to seeing the entries to the 2024 Challenge.