IM^{2}C 2024 Australian Judges' Commentary

The Australian IM^{2}C judges congratulate the 73 teams from 21 schools all across Australia who participated in the 2024 International Mathematical Modeling Challenge. Two teams, *Radar* from Brisbane Boys' College and *Algebros* from Northern Beaches Secondary College (Manly Campus), Sydney, have advanced to the international round. Team *BJRZ* from St. Joseph's College, were in a close third place.

The solution by the *Paw Patrol* team from Whitsunday Anglican School, was judged to be the top entrant from the Year 7 to 9 junior teams.

The 2024 Challenge – Picking the Perfect Pet

The challenge this year was about the welfare of our animal companions, pet ownership and the problem of abandonment. Teams had to define what constitutes a 'pet', build mathematical models to determine which households are prepared to own a pet, how many households are pet-ready, and forecast future pet ownership. Part one of the challenge was to build a model with up to 10 input factors to decide whether a given household is prepared to own a cat, validate the model with examples of households that do or do not qualify, and determine the current number of households prepared to own a cat in 3 countries or regions. Part two asked teams to adapt their models for four additional pet species and consider households with multiple pets. Part three asked for a model to predict pet ownership and retention, for the same species and countries, up to 15 years in the future.

The written components of the challenge included a summary, a letter to the 'Directors of the International Mission for the Maintenance and Care of Animals (IMMC-A)', and the complete solution within 20 pages. References and appendices were optional.

The use of Artificial Intelligence was permitted for the first time, together with a report listing the full questions posed to the AI and the AI-generated responses.

Interpreting the problem and creating models

Many teams interpreted the instruction to build models to mean creating a questionnaire or an instrument for gathering information from households. Although there were delightful, well-crafted surveys and even a fully functional, web-based implementation, they were not always based on adequate *mathematical* models of pet-owning households. A mathematical model would take responses about selected features of households from a survey and produce a decision about whether a household was pet-ready.

Some elegant mathematical models were created, using radar charts to compare features, neural networks to 'learn' features, or other functions of different factors that take into account the expected behaviour of those factors at lower and upper limits. Some models were disadvantaged by using rating scales with arbitrarily specified parameters such as weights or class intervals, for example, that do not convincingly model the real-world situation. Some entries had models that were over-mathematized, given the amount of data used, by using unnecessarily complicated functions and relations. The more competitive entries recognized that models need to be based on data, but 'model complexity' should not exceed 'data complexity'. Simpler models that are based on known processes (or allow for unknown interactions and uncertainties) are safer to use and tend to give better predictions than more complicated models based on solutions from other contexts, even if those have the right 'shape'.

Solving the problem, checking results and presenting findings

The judges were impressed by the quality of this year's winning entries – the ingenuity, the variety of approaches, the communication of ideas and the amount of background research done. Some parts, such as the mathematics of radar/spider charts and of neural networks, could have been considered more carefully, but the judges congratulate the teams for thinking 'outside the box' and doing a great job within the allowed time limit.

Most teams successfully solved the problem of combining factors with different units into a single model in reasonable ways by rescaling in proportion to data ranges and using reasonable assumptions but many assumed different factors to be uncorrelated or independent when they were probably not.

Checking the results was generally done by demonstrating that the models correctly classified households according to expectations, but a few teams also introduced simulated data and AI-generated data or considered statistical distributions of the data in describing the sensitivity of the outputs to variation in the inputs. Only one team modelled the *uncertainty* in projected pet ownership over time.

Clear and effective communication is the most important feature of a good report. This year's reports were generally well structured and pleasant to read, particularly when text was balanced with tables, diagrams and colour. Several teams included graphs without axis labels, although the software used for generating the graphs does allow labels to be added. In some cases, graphs included in an appendix should have been placed in the body of a report, as they were necessary for understanding and justifying the developed mathematical model.

Artificial Intelligence

AI did not play a major role in most reports3 and was mainly used for generating supporting programming code, rendering tables or tidying text. The AI-generated responses did not significantly contribute to the reports, and teams who used AI did not appear to have an advantage over teams who did not.

Finally

We congratulate all participating teams on their efforts during this challenge, we thank each school and team advisor for their support, and we hope every team member will continue to improve their skills in reasoning and communicating mathematically. We eagerly look forward to seeing the entries to the 2025 Challenge.