The UMAP Journal

The Journal of Undergraduate Mathematics and Its Applications

Modeling Newtonian Cooling

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Spring 2025 1

Publisher's Editorial

The Mathematical Modeling Mindset

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More Than a Process

Two days after stepping into my role as Executive Director of COMAP, I found myself in a classroom at Pui Kiu College in Hong Kong, sitting with five secondary school modeling teams and their advisors. These students had recently competed in the International Mathematical Modeling Challenge (IM^{2}C®), developing models to identify criteria for pet adoption. They were eager to share their experiences, and I was excited to understand how they approached their decision making. One student described how their family pet influenced the factors that they considered, while others spoke about the excitement of exploring different modeling approaches to tackle real-world problems. As they led me on a tour of their school, I was struck by how naturally they applied their modeling experience beyond mathematics, describing, for example, how it shaped their thinking while studying developmental biology in a lab setting.

That visit was just the beginning. In my first eight months at COMAP, I've met with educators, researchers, and students across different countries, regions, and states, each bringing a unique perspective on mathematical modeling. A Spanish colleague shared how her students, after competing in IM^{2}C, were so inspired by the experience that they created their own local modeling contest for younger students. Closer to home, I felt a personal sense of pride when a former student reflected on her experience in the Mathematical Contest in Modeling (MCM®) within a social media post. She described how the competition wasn't just about finding solutions but about leading, collaborating, and growing confident in the

The UMAP Journal 46 (1) (2025) 1–4.

process itself. She recalled how, at first, she and her teammates hesitated to share ideas; but as the competition progressed, they began to challenge and refine each other's models, ultimately producing a report that they were proud of, errors and all. Later, when she took an advanced statistics course, she recognized those errors; but instead of feeling discouraged, she connected what she was learning back to her modeling experience.

At the National Council of Teachers of Mathematics (NCTM) Annual Meeting, participants in a workshop that I co-facilitated shared another realization that I had often taken for granted: Modeling provides students with the opportunity to share their experiences in ways traditional math instruction rarely does. Some of their reflections stuck with me:

- "Defining a problem with no preconditions allows students to develop critical thinking."
- "Modeling creates new opportunities for students to grow in self-identity and agency."
- "It engages students in relevant and interesting work while elevating the knowledge they bring with them."
- "When students have choice and freedom in math, they find relevance."
- "Modeling activities build powerful thinkers."

These conversations, experiences, and reflections all pointed to the same essential realization: *Mathematical modeling is not just a process, it is a mindset.* It doesn't just equip students with problem-solving skills; it changes how they think about problem solving itself.

Defining the Mathematical Modeling Mindset

If you're reading this article, I expect that you already recognize that mathematical modeling is more than a set of techniques, it's a way of thinking about the world. Whether students are deciding how to structure a model for pet adoption, analyzing data in a science lab, or making sense of a complex social issue, they are engaging in an essential habit of mind: using mathematics to explore, explain, and solve problems. But this doesn't happen automatically. Developing a mathematical modeling mindset requires curiosity, creativity, and a willingness to embrace uncertainty.

At its core, a mathematical modeling mindset is about seeing the world through a mathematical lens: identifying patterns, simplifying complexity, and iteratively refining ideas. It's about recognizing that models are tools to help us make sense of real-world problems, even when they aren't perfect. And perhaps most importantly, it's about adopting a problem-solving approach that values exploration, adaptability, and collaboration.

This mindset is shaped by a set of interconnected habits and ways of thinking, some of which are listed below:

- **Curiosity and Inquiry:** Asking thoughtful questions, exploring ideas, and seeking to understand the "why" behind a problem.
- **Simplification and Assumption-Making:** Knowing how to strip away unnecessary details and focus on what truly matters.
- **Mathematical Representation:** Finding ways to express ideas mathematically, whether through equations, graphs, or computational models.
- **Pattern Recognition and Systems Thinking:** Seeing how different pieces fit together, identifying trends, and understanding interconnections.
- **Data and Computational Thinking:** Understanding how data informs decisions and how computational tools expand our ability to analyze complex problems.
- **Technological Fluency:** Using digital tools and AI-assisted reasoning to enhance modeling and problem-solving.
- **Mathematical Versatility:** Drawing on different areas of mathematics—statistics, geometry, discrete mathematics, analysis, and more—to develop stronger models.
- **Creativity and Adaptability:** Thinking outside the box, adjusting models as new information arises, and approaching challenges with flexibility.
- **Evaluation and Revision:** Testing ideas, reflecting on their effectiveness, and refining models to improve their accuracy.
- **Metacognition and Reflection:** Thinking about one's own reasoning and learning from the modeling process.
- **Collaboration and Communication:** Engaging with others, sharing ideas, and articulating solutions in meaningful ways.
- **Tolerance for Imperfection:** Recognizing that models are approximations, but that even an imperfect model can provide valuable insights.

Moving Forward with Intention

We don't always give mathematical modeling the credit that it deserves. Those of us who teach modeling understand its power to foster curiosity, decision-making, and exploration; yet we don't always articulate these benefits to others, whether to fellow educators, administrators, or students

themselves. We know that modeling is more than a set of techniques, but how often do we explicitly discuss the mindset it cultivates?

If we want to advance COMAP's mission to improve mathematics education with an emphasis on mathematical modeling, *we must be intentional about developing and supporting the mathematical modeling mindset*. This means providing tools and resources that meet the needs of those already engaged in modeling while also helping others recognize its broader value. It means designing learning environments where teachers feel empowered to create space for students to ask questions, make assumptions, refine their models, and engage in authentic problem-solving. It means shifting the focus from simply applying mathematical techniques to embracing the iterative, exploratory nature of modeling itself.

But just as importantly, we need to highlight what makes modeling uniquely powerful: its role in fostering quantitative communication, collaborative problem-solving, and informed decision-making. Modeling is not just about producing solutions; it's about negotiating ideas, testing assumptions, and refining understanding with a full array of mathematical, statistical, and computational tools.

As we move forward, we must be deliberate in how we develop and support this mindset, both inside and outside the classroom. By doing so, we ensure that mathematical modeling is not just seen as a tool, but as a way of thinking that equips students to navigate an increasingly complex world.

I'm excited to work alongside you to make this happen.

About the Author

Ben earned his B.S. and Ph.D. from the University of Iowa and received a master's degree in Mathematical Finance from Boston University. His research concentrates on developing new strategies and best practices for bringing innovation and active learning into K-16 STEM classrooms, with particular emphasis on mathematical modeling.

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