How working with a professional model affects students' views on the validity of simulation results

Christoph Lieben

Humboldt-Universität zu Berlin, Germany; c.lieben@hu-berlin.de

Keywords: mathematical literacy, modeling competencies, model uncertainty

Motivation

The increasing influence of mathematical modeling and simulations on political decision-making and public debates calls for consideration in our concept of mathematical literacy. Although students cannot be expected to develop professional models on their own, assessing their scope and validity is part of a comprehensive modeling competency. Within an interdisciplinary research project this study is part of a survey about students' perspective on the role of mathematics in politics. It examines how the (guided) use of a professional mathematical model for decision support affects students' views on the validity of simulation results of such models.

Theoretical and practical context

The influential Danish KOM project rendered mathematical modeling an elementary part of mathematical literacy and thereby identified two main components of modeling competency: The performative skills to actively construct own mathematical models on the one hand and the ability to de-construct given models, i.e., to analyze their foundations and evaluate their validity on the other (Niss & Blum, 2020). The participation in a so-called *Decision Theatre* promises to address the second component specifically by providing students with an existing mathematical model to work with. In this science communication format participants are encouraged to agree on political measures to face societal challenges. Based on their decisions, an existing model developed by scientists simulates future scenarios that are analyzed afterwards – in particular regarding the plausibility of the simulation results generated with this model. As part of this study, subjects participated in a Decision Theatre on mobility transition in Germany. The structure of this format and the *Mobility Transition Model* used there are described in detail in Wolf et al. (2023).

Method

For the study, a total of 56 students from 10th, 11th and 12th grade, 33 *before* (control group) and 23 *after* (test group) attending the Decision Theatre on mobility, were asked to complete a two-part task. This task deliberately dealt with a different content to capture modeling-related views rather than content-related knowledge. First, the students were shown a graph by James et al. (2021) that originally contained the projected incidence rate of tuberculosis in South Africa between 2000 and 2025 from eight different models. However, all but one reference curve were removed by the author and the students were asked to draw three curves that they thought might originate from the other models. The actual incidence rate up to 2021 (which was lower than any of the original projections) was then revealed to the students and they were asked to provide possible reasons for the deviations of the projections from reality. Their answers were then grouped into the categories "deviation due to methodological reasons", "deviation due to unpredictable developments" and "deviation due to preventive effects", and the categories' percentage of all statements was determined.

Results and discussion

As can be seen in Figure 1, the presumed curves of the students who participated in the Decision Theatre show a greater dispersion from the reference curve than those of the control group. Thus, students who have worked with a predictive model seem to expect greater deviations between the predictions of different models – suggesting that they generally assume a higher model uncertainty.

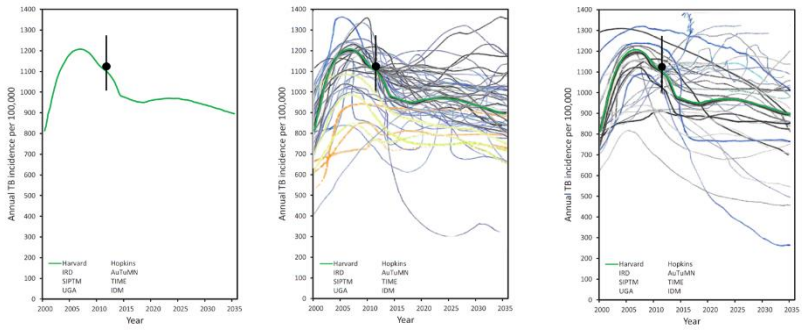

Figure 1: Reference curve (left) and cumulated guesses about the projections of different models by (11th grade) students who did not (middle) and those who did (right) participate in a Decision Theatre

Moreover, these students proportionately attributed the deviations both more often to methodological issues (32% vs. 19%, e.g., “Not enough data or information collected”) and to unpredictable developments (43% vs. 36%, e.g., “Cure was found unexpectedly”). Therefore, it stands to reason that the reduced confidence in model forecasts is partly due to an increased awareness of the challenges of building models and interpreting their results. It is also noteworthy that after working with the model, the students more often suspected a potential effect of the model itself on the course of the incidence (11% vs. 6%, e.g., “Adapted hygiene measures”, “Because they were deterred by the rapid increase”). This may indicate that they judge the relevance of modeling less in terms of predicting reality, and more in terms of what can be learned from the models. A follow-up study is now to ascertain how students assess the usefulness of mathematical modelling for political decision-making in general – and how the use of such a model in a Decision Theatre affects their assessment.

Acknowledgment

This work was supported by the Berlin University Alliance (BUA) [212_ExperLab_LR_3] and the Berlin Mathematical School (BMS).

References

James, L. P., Salomon, J. A., Buckee, C. O. & Menzies, N. A. (2021). The use and misuse of mathematical modeling for infectious disease policymaking: Lessons for the COVID-19 pandemic. *Medical Decision Making*, *41*(4), 379–385. https://doi.org/10.1177/0272989x21990391

Niss, M. & Blum, W. (2020). *The learning and teaching of mathematical modelling*. Routledge. https://doi.org/10.4324/9781315189314

Wolf, S., Fürst, S., Geiges, A., Laublichler, M., Mielke, J., Steudle, G., Winter, K. & Jaeger, C. (2023). The decision theatre triangle for societal challenges – an example case and research needs. *Journal of Cleaner Production*, *394*, 136299. https://doi.org/10.1016/j.jclepro.2023.136299