Model Building, Mathematization and Sense Making

Graduate Course, HBCSE, TIFR
January - May 2025, Semester 2

Instructors: Mashood KK, Shweta Naik and Deepa Chari

Course Code: SCE207.2

Credits: 2

Duration: 12 X 2 hr Sessions

Day & Time: Friday 11 am - 1 pm [Starting from 10 January, 2025]

Outline:

Model building, mathematization and sensemaking are integral to knowledge construction in science. These are important strands discussed in science and mathematics education research literature. This course aims to introduce students to some of the core issues pertaining to , an overview of different discourses related to it and provide a discussion platform that will enrich work involving related threads being pursued at HBCSE.

Some of the key points which the course focuses on are:

- Modelling as the epistemology of science: The practise of science fundamentally involves design/construction, evaluation and revision of models. However, such an understanding of the nature of science is not very common. The course emphasises the centrality of modelling to science and tries to build a corresponding epistemological narrative of science.

- Modelling as an epistemological framework for science education: The disconnect between the actual practice of science and how science education is structured is a matter of great pedagogical concern. The course discusses frameworks that advocate a pedagogy of science based on modelling, which has the potential to narrow this gulf.

- Computational thinking and modelling: Computational thinking and associated novel approaches to modelling have become an integral part of the current scientific and engineering practise. The course will discuss basic tenets of computational thinking relevant to science education like the different thinking skills underlying it and their connection to thinking in science and mathematics.

Learning Goals:

- Understand the centrality of mathematization and model buildling to the practise of science.

- Develop familiarity with issues pertaining to modelling based approaches in science education and their epistemological underpinnings.

- Develop familiarity with the literature on mathematical sense making and mathematization.

- Introduction to computational thinking and simulation as a modelling approach.

- Develop familiarity with a spectrum of mathematical modelling tasks from formal word problems to “Fermi problems”

Readings:

1) Select chapters from Knuuttila, T., Carrillo, N., & Koskinen, R. (Eds.). (2024). The Routledge Handbook of Philosophy of Scientific Modeling (1st ed.). Routledge. https://doi.org/10.4324/9781003205647

2) NCERT Appendix on Mathematical Modeling, https://ncert.nic.in/textbook/pdf/kemh1a2.pdf

3) Sfard, A. (2007). When the rules of discourse change, but nobody tells you: Making sense of mathematics learning from a commognitive standpoint. *The journal of the learning sciences*, *16*(4), 565-613. https://www.tandfonline.com/doi/pdf/10.1080/1050840070152525

4) Uhden, O., Karam, R., Pietrocola, M., & Pospiech, G. (2012). Modelling mathematical reasoning in physics education. *Science & Education*, *21*, 485-506. https://link.springer.com/article/10.1007/s11191-011-9396-6

5) Passmore, C., Gouvea, J. S., & Giere, R. (2014). Models in science and in learning science: Focusing scientific practice on sense-making. In *International handbook of research in history, philosophy and science teaching* (pp. 1171-1202). Springer, Dordrecht.

6) Farris, A. V., Dickes, A. C., & Sengupta, P. (2019). Learning to interpret measurement and motion in fourth grade computational modeling. *Science & Education*, *28*, 927-956. https://link.springer.com/content/pdf/10.1007/s11191-019-00069-7.pdf

7) Morrison, M. (2015). Reconstructing reality: Models, mathematics, and simulations. Oxford Studies in Philosophy

8) Gowers, T. (2002) Mathematics – a very short introduction. OUP. Chapters 1, 2, (17 pages)

9) Learning through Problems – doing Mathematics two sessions by Shweta Naik (these sessions will involve developing models to solve problems and meaning making through problem solving)

10) Sfard, A. (2007). When the rules of discourse change, but nobody tells you: Making sense of mathematics learning from a commognitive standpoint. The Journal of the Learning Sciences, 16(4), 565-613.

11) Clarke, D. J., Waywood, A., & Stephens, M. (1993). Probing the structure of mathematical writing. Educational studies in mathematics, 25(3), 235-250.

12) Niss, M., & Blum, W. (2020). The learning and teaching of mathematical modelling. Routledge.

Class Structure and Assessment:

The course will discuss one paper per session. The crediting students will take turns in presenting the paper and leading the discussion. The auditing students can volunteer to present, but is not mandatory. The presentation and discussion have to be structured in such a way that maximum participation from everyone and thereby discussion is enabled.

Assessment is based on the following accounts:

1) Presentation of papers
2) Participation in discussion
3) A final term paper whose expected length is 3000 -5000 words . For this students can choose a theme related to modelling, in consultation with instructors, that is of interest to them.
4) Problem-solving and developing models