An Introduction to Modelling in Science Education

Graduate Course, HBCSE, TIFR
January - May 2019, Semester 2

Instructors: Mashood K. K. and Deepa Chari

Credits: 2

Duration: 15 Weeks

Time: Tuesdays, 3.30 - 5.30 pm

Outline:

Modelling is an important strand in science education research literature. This course aims to introduce students to some of the core issues pertaining to modelling and an overview of different discourses related to it in science education. Some of the key points which the course focusses on are:

- Modelling as the epistemology of science: The practise of science fundamentally involves 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 builds a corresponding epistemological narrative of science. It would not be far fetched to say that students spend years learning disciplines like physics, without appreciating that the subject is fundamentally about mathematically modelling natural phenomena.

- Modelling as an epistemological framework for science education: The disconnect between the actual practise of science and how science education is structured is a matter of great pedagogical concern. The course discusses frameworks that advocates a pedagogy of science based on modelling, which has the potential to narrow this gulf. Prominent among them is the Next generation Science Standards that puts a heavy emphasis on modelling in science and engineering education. We also discuss how modelling as a pedagogy enables the `product to practise' transition (a theme in philosophy of science circles) and thereby promotes a more authentic science education.

    - There exists curricula and instructional materials developed with modelling as the guiding epistemological framework that have been proven highly successful in contexts elsewhere. The course will discuss some of the exemplars in this regard like the Modelling instruction at Arizona State University developed by Hestenes et. al. and the work by Richard Lehrer and his group. The possibilities and challenges for similar endeavours in the Indian context will also be part of the discussion.

- Critiquing modelling based instruction: Though learning and instructional approaches based on modelling claims to be true to students and true to science on many accounts, there are problematics that needs critical appraisal. The course discuss constructs like epistemic agency, epistemic oppression etc which enables such a critical appraisal. Instructional approaches as well as overarching frameworks like the Next generation Science Standards which emphasise modelling are looked into with a critical lens.

- 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. An overview of the role of computational models and simulations as teaching, learning aids and as problem solving approaches will be done. Some of the popular learning platforms in this regard like PhET, Netlogo etc. will be briefly looked into.

Learning Goals:

- Understand the centrality of modelling to the practise of science.
- Develop familiarity with issues pertaining to modelling based approaches in science education and their epistemological underpinnings.
- Introduction to computational thinking and simulation as a modelling approach.

Readings:

1) 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.

2) Gilbert, J. K. (2004). Models and modelling: Routes to more authentic science education. *International Journal of Science and Mathematics Education*, *2*(2), 115-130.

3) Harrison, A. G., & Treagust, D. F. (2000). A typology of school science models. *International Journal of Science Education*, *22*(9), 1011–1026.

4) Hestenes, D. (2006). Notes for a modeling theory. In Proceedings of the 2006 GIREP conference: Modeling in physics and physics education (Vol. 31, p. 27). Amsterdam: University of Amsterdam.

5) Guy-Gaytán, C., Gouvea, J. S., Griesemer, C., & Passmore, C. (2019). Tensions Between Learning Models and Engaging in Modeling. *Science & Education*, *28*(8), 843-864.

6) Miller, E., Manz, E., Russ, R., Stroupe, D., & Berland, L. (2018). Addressing the epistemic elephant in the room: Epistemic agency and the next generation science standards. *Journal of Research in Science Teaching*, *55*(7), 1053-1075.

7) Russ, R. S. (2014). Epistemology of science vs. epistemology for science. *Science Education*.

8) Weintrop, D., Beheshti, E., Horn, M., Orton, K., Jona, K., Trouille, L., & Wilensky, U. (2016). Defining computational thinking for mathematics and science classrooms. *Journal of Science Education and Technology*, *25*(1), 127-147.

9) Sengupta, P., Kinnebrew, J. S., Basu, S., Biswas, G., & Clark, D. (2013). Integrating computational thinking with K-12 science education using agent-based computation: A theoretical framework. *Education and Information Technologies*, *18*(2), 351-380.

10) Wing, J. M. (2008). Computational thinking and thinking about computing. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 366(1881), 3717-3725.

11) Frigg, R., & Hartmann, S. (2006). Models in science. *Stanford Encyclopedia of Philosophy.*

Additional materials and references:

1) Modelling Instruction Program website by Hestenes et al., at Arizona State University.

http://modeling.asu.edu/

2) How do I promote student modelling? Web seminar by Cynthia Passmore

www.youtube.com/watch?v=lHa6GZmYJo0

3) National Research Council. 2012. A **Framework** for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Washington, DC: The National Academies Press.

4) Nersessian, N. J. (2010). Creating scientific concepts. MIT press.

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

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) Two term papers - a mid term and a final term paper. The topic of mid-term paper will be assigned by the instructors and the expected length is around 1500 words. It will have half the weightage in score compared to the final term paper, whose expected length is 3000 -5000 words . For the final term paper students can choose a theme related to modelling, in consultation with instructors, that is of interest to them.

Both instructors will independently grade the students and the scores will then be averaged.