

OC4 Science Education

About the Course

This course is not seen as a purely pedagogy course. It does a more critical evaluation of science education – its aims, perspectives and practices. The course has two major parts. One is a focus on science education -- the why, what and how. To do this we draw from innovative practices in India and outside as well as research in science education itself.

Enquiry into these areas has led us today to understand that a critical enquiry into what is science is as crucial as what is to be taught as science. So another important part of the course is interrogation of the nature of science itself – an analysis of what is commonly understood as well as the understanding emerging from various critiques from different locations.

The overall focus of the course is with an intention of stimulating discussion on what science education could be for students, teachers and researchers beyond what science education should be – a search for effective tools and implementable models.

Unit 1

Science teaching and learning

The unit deals with discussing the influence of the constructivist paradigm on science education and its critique. We first engage with studies from constructivist paradigm about what conceptions children develop about scientific phenomena. Further the implications for teaching science according to constructivist principles are discussed through approaches like conceptual change approach, Inquiry, model based reasoning, collaborative learning, apprenticeship model. The role of discourse used in classrooms to support/constrain science learning is also discussed. We then engage with critiques of constructivism from different perspectives in terms of its limitations in its use in classroom along with potential problems in its philosophical underpinnings. This leads to raising questions like “What is Science?” and “What is the method of science?” which will be further engaged in other units.

Essential Readings

1. Carr, M., Barker, M., Bell, B., Biddulph, F., Jones, A., Kirkwood, V., Pearson, J., & Symington, D. (1994). The constructivist paradigm and some implications for science content and pedagogy. In P. Fensham, R. Gunstone, & R. White (eds.) *The Content of Science* (pp. 147-160). London: The Falmer Press.
2. Driver, R. Guesne, E. & Tiberghien, A. (1985). Some features of children’s ideas and their implications for teaching. In R. Driver, E. Guesne, & A. Tiberghien (eds.) *Children’s Ideas in Science* (pp. 147-160), Open University Press, Milton Keynes. (Available in the CD).
3. Scott, P. H., Mortimer, E. F., & Aguiar, O. G. (2006). The tension between authoritative and dialogic discourse: A fundamental characteristic of meaning making interactions in high school science lessons. *Science Education*, 90(4), 605-631.
4. Jenkins, E. W. (2001). Constructivism in school science education: Powerful model or the most dangerous intellectual tendency?. *Science Education and Culture*. Kluwer, 153-164.
5. Matthews, M. R. (2002). Constructivism and science education: A further appraisal. *Journal of Science Education and Technology*, 11(2), 121-134.
6. Leach, J. and Scott, P. (2003). Individual and sociocultural views of learning science. *Science & Education*, 12, 91-113.

Additional Readings

1. Phillips, D. C. (1995). The good, the bad, and the ugly: The many faces of constructivism. *Educational researcher*, 5-12.
2. Leach, J. (2007). The relationship of theory and practice in designing, implementing and evaluating teaching sequences: Learning from the examples that don't work. *ESERA 2007 Conference*.
3. Duit, R. and Treagust, D. (2003). Conceptual change: A powerful framework for improving science teaching and learning. *International Journal of Science Education*, 25(6), 671-688.
4. Scott, P, Asoko, H., Driver, R., & Emberton, J. (1994). Working form Children's Ideas : Planning and Teaching a Chemistry Topic from a Constructivist Perspective. In Peter Fensham, Richard Gustone & Richard White (eds.). *The Content of Science, A Constructivist Approach to its Teaching and Learning* (201-220). The Falmer Press, London.
5. DiSessa, A. (2006). A history of conceptual change research. In *Cambridge Handbook of the Learning Sciences* (pp. 265-281). Cambridge University Press.
6. Osborne, J. F. (1996). Beyond Constructivism. *Science Education*, 80, 53-82.
7. Leach, J. & Lewis, J. (2002). The role of students' epistemological knowledge in the process of conceptual change in science. In *Reconsidering conceptual change in science* (pp. 11-18). Kluwer.
8. Anderson, R. (2002). Reforming science teaching: What research says about inquiry. *Journal of Science Teacher Education*, 13(1), 1-12.
9. Gilbert, J. (2004). Models and modelling: routes to more authentic science education, *International Journal of Science and Mathematics Education*, 2, 115–130.

Unit 2

Perspectives on science education

What are the aims of science education? How do these determine the perspectives, curriculum design and assessment patterns in school education? Education through science and education in science – influence of ideas and ideologies globally. What is scientific literacy? Its value and importance in education and how does it get translated into school programmes and curricula? What are the impacts of the various critiques and philosophies on the nature of science education? Discussion on the unresolved tensions and curriculum issues. What are the main curricular debates in school science? How are science curricula and textbooks constructed and what concerns have informed curriculum inquiry into science education. The above to be discussed in the context of some innovative programs e.g. HSTP, HBCSE (Small Science), NCF (2006).

Essential Readings

1. Matthews, Michael. (1998). The nature of science and science teaching. In *International Handbook of Science Education* (pp. 981-999). Kluwer.
2. Allchin, Douglas (1999). Values in Science : An educational perspective. *Science & Education*, 8, 1-12.
3. Pedretti, Erminia and Nazir, Joanne. (2011), Currents in STSE education: Mapping a complex field, 40 years on. *Science Education*, 95, 601–626.

Additional Readings

1. Elkana, Yehuda (2000). Science, philosophy of science and science teaching. *Science & Education*, 9, 463-485.
2. Woolnough (1994). Effective science teaching. Open University Press: Buckingham UK, 11 – 26, 99 - 115.

3. Fensham, Peter J., Gunstone, Richard F. and White, Richard T. (1994). Introduction. In *The Content of Science: A Constructivist Approach to its Teaching and Learning* (pp. 1 – 13). The Falmer Press: London.
4. Weinstein Matthew (2007). Finding science in the school body: Reflections on transgressing the boundaries of science education and the social studies of science. *Science Education*. Wiley Periodicals, 389-403.
5. Levinson, R. (____) Towards a pedagogical framework for the teaching of controversial socio-scientific issues to secondary students in the age range 14-19.
6. Roberts, D.A. (2007). Scientific Literacy/Science Literacy. In S.K. Abell & N.G. Lederman (Eds.), *Handbook of Research on Science Education* (pp. 729-780), A project of the National Association for Research in Science Teaching.
7. Duschl, R. (2000). Making the nature of science explicit. In Millar, R., Leach, J. and Osborne, J. (Eds.), *Improving Science Education* (pp. 187-205). Open University Press.
8. Hodson, Derek (2003). Time for action: Science education for an alternative future, *International Journal of Science Education*, 25(6), 645-670.

Unit 3

Nature of Science

What is science? How is science different from or similar to other forms of knowledge production? How do philosophies of science affect the nature of science? How do we historically locate the enterprise of science? What is the interface of science with society? These questions will be addressed through two modes, both in conversation with each other.

One is the disciplinary mode through a study of History, Philosophy and Sociology of Science (HPS). While doing HPS we hope to talk about some of the key concepts and also the ways in which these disciplines have evolved and grown over a period of time and also their inbuilt critiques.

The other mode draws from epistemologies arising from lived experiences of some marginalised communities and movements. We address this using critiques arising from environment, reproductive health and people's science movements as well as issues of representations of caste, race, gender within science. We use the feminist critiques of science as an example of understanding the contribution of these to the creation of newer understandings of science.

3.1 Philosophy of science

Essential Readings

1. Godfrey-Smith, Peter. (2003). Chapter 1, 2, 3. In *Theory and Reality* (pp. 1-56). University of Chicago Press. (Available in the CD)
2. Kulkarni, S. G. (____) Philosophy of science: Issues and perspectives. Department of Philosophy, University of Hyderabad.
3. Godfrey-Smith, Peter. (2003). Lakatos, Laudan, Feyerabend & Frameworks, Chapter 7. In *Theory and Reality* (pp. 102-121). University of Chicago Press. (Available in the CD)
4. Godfrey-Smith, Peter. (2003). Empiricism, Naturalism and Scientific Realism, Chapter 15. In *Theory and Reality* (pp. 219-231). University of Chicago Press. (Available in the CD)

Additional readings

1. Okasha, Samir. (2002). *Philosophy of Science: A Very Short Introduction*. Oxford University Press.
2. Quine, W. V. (1951). Main trends in recent philosophy: Two dogmas of empiricism, *The Philosophical Review*, 60(1), 20-43.
3. Driver, R., Leach, J., Millar, R. and Scott, P. (1996). *Young People's Images of Science*. Open University Press.

3.2 History of Science

Essential readings

1. Nye, Mary Jo (2008). Introduction: The modern physical and mathematical sciences. In Nye, Mary Jo (Ed.) *The Cambridge History of Science, Vol. V* (pp. 1-20). Cambridge University press. (Available in the CD)
2. Raina, Dhruv. (2006). Towards a global history of science: The relationship between science, its history and theory of history. In Madhusree Dutta and Smriti Nevatia (eds), *Sites and Practices: An Exercise in Cultural Pedagogy* (pp. 232-242). Majlis: Mumbai.

Additional Readings

1. Niaz, Mansoor (2000). The oil drop experiment: A rational reconstruction of the Millikan-Ehrenhaft controversy and its implications for chemistry textbooks. *Journal of Research in Science Teaching*, 37(5), 480-508.

3.3 Sociology of Science

Essential readings

1. Bucchi, Massimiano. (2004). *Science in Society: An Introduction to social studies of science*. Routledge. (Available in the CD).
2. Allchin, Douglas. (2004). Should the sociology of science be rated X?, *Science Education*, 88, 934-946.
3. Godfrey-Smith, Peter. (2003). The challenge from sociology of science, Chapter 8. In *Theory and Reality* (pp. 122-135). University of Chicago Press. (Available in the CD)

Additional Readings

1. Snow, C. P. (1990). The Two Cultures. *Leonardo*. 23(2/3), 169-173.
2. Labinger, Jay A. & Collins, Harry (2001). Introduction. In *The one Culture? : A Conversation about Science* (pp. 1-12). University of Chicago Press.
3. Bloor, David. (1976). Chapter 1, 2 and 3. In *Knowledge & Social Imagery* (pp. 1-47), Routledge & Kegan Paul, London.
4. Pinch, Trevor. (2001). Does science studies undermine science. In Labinger, Jay A. & Collins, Harry (Eds.) *The one Culture? : A Conversation about Science* (pp. 13-26). University of Chicago Press.
5. Nandy, Ashis. (1990). Introduction: Science as a reason of state. In Nandy, A. (Ed.) *Science, Hegemony and Violence* (pp. 1-23). Oxford University Press, USA.
6. Shiva, Vandana (1990). Reductionist science as epistemological violence. In Nandy, A. (Ed.) *Science, Hegemony and Violence* (pp. 232-256). Oxford University Press, USA.

7. Nanda, Meera (1997). Against social deconstruction of science: Cautionary tales from the third world. *Monthly Review*.

3.4 Feminist and other critiques of Science

Essential readings

1. Shah, Chayanika (2012). From numbers to structures: Navigating the complex terrains of science, education and feminism. *Contemporary Education Dialogue* 9(2), 145-171.
2. Keller, Evelyn Fox (2001). Gender and Science: An Update. In Wyer Mary et al (eds). *Women, Science and Technology: A Reader in Feminist Science Studies* (pp. 132-142) Routledge: New York.

Additional Readings

1. Subramaniam, Banu (2001). Snow Brown and the Seven Detergents. In Wyer Mary et al (eds) *Women, Science and Technology: A Reader in Feminist Science Studies* (pp. 36-41). Routledge: New York.
2. Barres, Ben. A. (2006). Does Gender Matter?, *Nature*, 442(13 July), 133-136.
3. Harding, Sandra (1991). *Whose Science? Whose Knowledge? Thinking from Women's Lives*. Cornell University Press: New York, 296-312.
4. Longino, Helen E. (1989). Can there be a Feminist Science?. In Nancy Tuana (Ed.) *Feminism and Science* (pp. 45-57). Indiana University Press: Bloomington.
5. Weasel, Lisa (2001). Dismantling the self/other dichotomy in science: Towards a feminist model of the immune system. *Hypatia*, 16(1), 27-44.