Title: Introduction to STME Research
Credits: 4 (~ 44 hours, 2 contact sessions per week of 2 hours each)
Semester 1: August 1 to November 30

Objectives:

1. Motivation for STME research (Why STME research is necessary?)
2. Exposure to research in STME and research at HBCSE
3. Overview of issues (central themes) in science, technology and mathematics education research

Concepts/ Issues/ Skills/ Questions:

- Ability to search research materials in STME (article, chapter, etc.)
- Recognise the context of research (broad areas of research, and issues addressed by the article)
- Develop ability to follow cross references of interest, and identify those that are significant or have broad reviews
- Conduct literature review
- Identify some of the central themes in STME research, eg. Student conceptions, Conceptual change, Teacher education, Students' /Teachers' attitudes to STME, Classroom interaction and assessment, Application to real-world contexts, STME and society, Modelling, Representations, Nature of Science etc.
- Develop familiarity with the structure and nature of argumentation in various STME research topics.

Classroom sessions:

The course will broadly cover the 9 themes below. There will be at least 2 sessions per theme. Each session will focus on one selected paper which all the participants are expected to read. Based on the reading a short write-up (~ 250 words) has to be submitted by the students, prior to the session which notes down the interesting, important and difficult aspects of the paper. The session will begin with a brief discussion of the summary of the paper based on the short write-up. This will be followed by in-depth discussion of the salient arguments and features of the paper. Though the instructor will moderate, the discussion will be lead by all participants in a rotating manner. In few sessions we may invite experts to lead discussions based on a paper they select in their area of expertise.

Readings:

Theme 1:Education and Society

1. K. Krishna (2010). Culture, state and girls: An educational perspective. *Economic and Political Weekly,* Vol 45, Issue No. 17, April 24, 2010.
2. Fennema, E. H., & Sherman, J. A. (1978). Sex-related differences in mathematics achievement and related factors: A further study. *Journal for Research in Mathematics Education*, 189-203.

3. Reiss, M. (2008). Should science educators deal with the science/religion issue? *Studies in Science Education*, 44 (2). pp. 157-186.
4. Greer, B. (2011). What is Mathematics Education for? In K. Subramaniam & A. Majumdar (Eds.) epiSTEME 3 – *Proceedings of the International Conference to Review Research in Science, Technology and Mathematics Education*. MacMillan.
5. George, A. (2013). Illustrating social studies in textbooks. *Contemporary Education Dialogue.* 10(1), pp.147–153.

6. Aikenhead, G. & Jegede, O. (1999). Cross-cultural science education: A cognitive explanation of a Cultural Phenomenon. *Journal of Research in Science Teaching*, 36(3), pp. 269–287.
7. Hodson, D. (2003) Time for action: Science education for an alternative future. *International Journal of Science Education,* Vol. 25, Issue 6. pages 645-670.

Theme 2:Out-of-school and connections to real world

1. Rennie, L. (2007). Learning science outside of school. *In S. Abell & N. Lederman(Eds.). Handbook of Research on Science Education, pp. 125-167, Taylor & Francis.*

2. Tunnicliffe, S. D., Lucas, A. M. and Osborne, J. F. (1997). School visits to zoos and museums: a missed educational opportunity?, *International Journal of Science Education* 19(9), 1039-1056.
3. Braund, M. & Reiss, M. (2006). Towards a more authentic science curriculum: The contribution of out-of-school learning, *International Journal of Science Education*, 28(12), 1373-1388.
4. Milne, C. (1998). Philosophically correct science stories? Examining the implications of heroic science stories for school science. *Journal of Research in Science Teaching*, *35*(2), 175-187.
5. Falk, J. & Dierking, L. (2012). Lifelong Science Learning for Adults: The Role of Free-Choice Experiences, In B. Fraser, K. Tobin & C. McRobbie (Eds.), *Second International Handbook of Science Education,* Part 1, pp. 1063-1079. Springer.
6. Allchin, D. (1999). Values in Science: An educational perspective, *Science & Education,* 8, 1-12.

Theme 3: Teacher Education

1. Wallace, J. & Loughran, J. (2012). Science Teacher Learning, In B. Fraser, K. Tobin & C. McRobbie (Eds.), *Second International Handbook of Science Education,* Part 1, pp. 295-306. Springer.
2. Batra, P. (2013). Teacher Education and Classroom Practice in India: A Critique and Propositions. In S. Chunawala & M. Kharatmal (Eds.). *The epiSTEME Reviews --- Research Trends in Science, Technology and Mathematics Education, Volume 4*. India: Narosa.

3. (iii) Brown, P., Friedrichsen, P. & Abell, S. (2013). The development of prospective secondary biology teachers PCK. *Journal of Science Teacher Education*, 24(1), pp. 133-155.

4. (iv) Kang, E., Bianchini, J. & Kelly, G. (2013). Crossing the border from science student to science teacher: Preservice teachers' views and experiences learning to teach inquiry. *Journal of Science Teacher Education,* 24(3), pp. 427-227
5. Crippen, K. (2012). Argument as professional development: Impacting teacher knowledge and beliefs about science. *Journal of Science Teacher Education*, 23(8), pp. 847-866.
6. Lumpe, A., Czerniak, C., Haney, J., & Beltyukova, S. (2012). Beliefs about teaching science: The relationship between elementary teachers' participation in professional development and student achievement. *International Journal of Science Education*, 34(2), 153-166.
7. J. Stigler & J. Hiebert. (2009). Images of teaching, In, The teaching gap: Best ideas from the world's teachers for improving education in the classroom, Published by Simon and Schuster.

Theme 4:Student conceptions

1. Smith III, J. P., DiSessa, A. A., & Roschelle, J. (1994). Misconceptions reconceived: A constructivist analysis of knowledge in transition. *The journal of the learning sciences*, *3*(2), 115-163.
2. Loverude, M. E., Kautz, C. H., & Heron, P. R. (2003). Helping students develop an understanding of Archimedes' principle. I. Research on student understanding. *American Journal of Physics*, *71*(11), 1178-1187.
3. Mahajan, B. S. & Chunawala, S. (1999). Indian secondary students' understanding of different aspects of health. *International Journal of Science Education,* 21(11), 1155-1168.
4. Rowell, P. (2004). Developing technological stance: Children's learning in technology education, *International Journal of Technology and Design Education*, 14, 45–59.
5. Mintzes, J., Wandersee, J. & Novak, J. (2001) Assessing understanding in biology. *Journal of Biological Education*, 35:3, 118-124
6. Sirnoorkar, A., Mazumdar, A., & Kumar, A. (2016). Students' epistemic understanding of mathematical derivations in physics. *European Journal of Physics*, *38*(1), 015703.
7. Eilks, I., Moellering, J., Valanides, N. (2007) Seventh-grade students' understanding of chemical reactions: Reflections from an action research interview study. *Eurasia Journal of Mathematics, Science & Technology Education*, 2007, 3(4), 271-286
8. Subramaniam K. and Padalkar S. Visualisation and Reasoning in Explaining the Phases of the Moon *International Journal of Science Education* (2009), 31(3): 395-417
9. Sudhir Panse, Jayashree Ramdas and Arvind Kumar Alternative Conceptions in Galilean relativity: frames of reference *International Journal of Science Education* (1994), 16 (1): 63-82

Theme 5: Conceptual Change

1. diSessa, A. A. (2006). A History of Conceptual Change Research: Threads and Fault Lines. In R. K. Sawyer (Ed.), *The Cambridge handbook of: The learning sciences* (pp. 265-281). New York, NY, US: Cambridge University Press.

2. Vosniadou, S. (2012). Reframing the Classical Approach to Conceptual Change: Preconceptions, Misconceptions and Synthetic Models, In B. Fraser, K. Tobin & C. McRobbie (Eds.), *Second International Handbook of Science Education,* Part 1, pp. 119-130. Springer.

3. Chi, M.T.H. (2008). Three types of conceptual change: Belief revision, mental model transformation, and categorical shift. In S. Vosniadou (Ed.), *Handbook of research on conceptual change* (pp. 61-82). Hillsdale, NJ: Erlbaum.

4. Duit R. & Treagust D. (2012) : How can conceptual change contribute to theory and practice in science education ? In B. Fraser, K. Tobin & C. McRobbie (Eds.), *Second International Handbook of Science Education,* Part 1, pp. 107-118. Springer.

Theme 6: Language and Science Education Research

1. Amin, T.G., 2009. Conceptual metaphor meets conceptual change. *Human Development*, *52*(3), pp.165-197.
2. Tobin, Kenneth, and Deborah J. Tippins. "Metaphors as seeds for conceptual change and the improvement of science teaching." *Science Education* 80.6 (1996): 711-730.
3. Nunez, R. E., & Lakoff, G. (2013). The metaphorical structure of mathematics: Sketching out cognitive foundations for a mind-based mathematics. In *Mathematical reasoning* (pp. 29-98). Routledge.
4. Brookes DT, Etkina E. Using conceptual metaphor and functional grammar to explore how language used in physics affects student learning. Physical Review Special Topics-Physics Education Research. 2007 May 15;3(1):010105.
5. Blown E.J. and Bryce T.G.K Switching between everyday and scientific language *Research in Science Education* (2017) 47:621–65

Theme 7:Classroom Interaction and Assessment

1. Ramadas, J. & Kulkarni, V. (1982). Pupil participation and curriculum relevance, Journal of Research in Science Teaching, 19 (5), 357-365, 1982
2. Jones, A. (2012). Technology in Science Education: Context, Contestation and Connection, In B. Fraser, K. Tobin & C. McRobbie (Eds.), *Second International Handbook of Science Education,* Part 1, pp. 811-822. Springer

3. Hestenes, D., Wells, M., & Swackhamer, G. (1992). Force concept inventory. *The physics teacher*, *30*(3), 141-158.
4. Spendlove, D. (2008). Creativity in education: a review. *Design and Technology Education: An International Journal,* 10(2).
5. Larson, J. (1995). Fatima's Rules and Other Elements of an Unintended Chemistry Curriculum. Paper presented at *American Education Research Association (AERA)*, San Francisco.
6. Kawalkar, A. & Vijapurkar J. (2013)., Scaffolding Science talk: The role of teachers' questions in the Inquiry Classroom, *International Journal of Science Education*, 35(12) 2004-2027.
7. Osborne, J. (2012). The Role of Argument: Learning How to Learn in School Science. In B. Fraser, K. Tobin & C. McRobbie (Eds.), *Second International Handbook of Science Education,* Part 1, pp. 933-949. Springer.

Theme 8: Modelling and Representations in Science Education

1. 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.
2. Jakob Christensen-Dalsgaard & Morten Kanneworff (2009) Evolution in LEGO®: A Physical Simulation of Adaptation by Natural Selection. *Evolution: Education and Outreach*. Vol 2, 518-526.
3. Khunyakari R., Mehrotra S., Chunawala S. and Natarajan C. (2007) Design and technology productions among middle school students: an Indian experience International Journal of Technology and Design Education 17:5–22
4. Rahaman, J., Agrawal, H., Srivastava, N., Chandrasekharan, S. (2018). Recombinant enaction: manipulatives generate new procedures in the imagination, by extending and recombining action spaces. *Cognitive Science*, 42(2), 370–415.
5. Tweney, R. D. (2017). Metaphor and Model-Based Reasoning in Mathematical Physics. In *Springer Handbook of Model-Based Science* (pp. 341-353). Springer, Cham.

Theme 9: History and Nature of Science in Science Education

1. Lederman, N. G., Abd‐El‐Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of nature of science questionnaire: Toward valid and meaningful assessment of learners' conceptions of nature of science. *Journal of research in science teaching*, *39*(6), 497-521.
2. Matthews MR. Idealisation and Galileo's pendulum discoveries: Historical, philosophical and pedagogical considerations. Science & Education. 2004 Nov 1;13(7-8):689-715.
3. Monk M, Osborne J. Placing the history and philosophy of science on the curriculum: A model for the development of pedagogy. Science education. 1997 Jul;81(4):405-24.

4. Abd-El-Khalick, F., Bell, R. L., & Lederman, N. G. (1998). The nature of science and instructional practice: Making the unnatural natural. *Science education*, *82*(4), 417-436.

Assessment:

Students will be assessed based on their write ups (25%), participation in discussion (30 %), assignments (20 %) and final term paper (25 %)

Handbooks:

- *Handbook of research on conceptual change* (pp. 61-82). Hillsdale, NJ: Erlbaum.
- *The Cambridge handbook of: The learning sciences* (pp. 265-281). New York, NY, US: Cambridge University Press.
- *Fraser, B., Tobin, K. & McRobbie, C. (Eds.) (2012). Second International Handbook of Science Education, Springer.*

Journals:

- American Journal of Physics.
- Contemporary Education Dialogue.
- Cognitive Science
- Design and Technology education : An International Journal
- Economic and political Weekly.
- European Journal of Physics.
- Eurasia journal of Mathematics, Science and Technology Education.
- Evolution: Education and Outreach
- Human Development
- International journal of Science Education.
- International journal of Technology and Design Education.
- Journal for Research in Mathematics Education.
- Journal of Biological Education.
- Journal of Research in Science Teaching.
- Journal of Science Teacher Education.
- Science and Education.
- Science Education.
- Studies in Science Education.