- **Course Name:** Introduction to Science and Mathematics Education Research
- **Credits:** 4 Credits
- **Number of weeks:** 12 weeks
- **Hours per week:** 5 hours (2 classes of 2.5 hours)
- **Instructor(s) Names:** Prof. Aniket Sule
- **Tutor(s) Names:** Dr. Akshat Singhal
- **Course Number:** SCE101.2
- **Timings:** Wednesday (2:30 PM to 5 PM) and Friday (2:30 PM to 5 PM)
- **Starting from:** August 23, 2023
- **Learning Outcomes:**
    - Motivation for STME research (Why STME research is necessary?)
    - How is STME research conducted?
    - Learning to parse education research literature
        - Exposure to current research in STEM education
        - Education research at HBCSE
- **Evaluation Process:**
    - Classroom participation 20%
    - Student presentations 40%
    - Term paper 40%
- **Work Submission Deadlines:** For term paper – 15 days after the last class.
- **Course Outline:**
    - Module 1:
        - Basic Overview
          Why Education Research?, Research Question and Research Design, Founding principles of educational studies, What is qualitative research and quantitative research? Evaluation and Action Research, Publication of Research and Ethics
            - Slater, S., Slater, T., Heyer, I. & Bailey, J. (2015). Conducting Astronomy Education Research: An Astronomer's Guide.
        - Different dimensions of educational research (research reading)
            - Anderson, C. W. (2013). Perspectives on science learning. In *Handbook of research on science education* (pp. 17-44).

      For Modules 2, 3 and 4 - the aim is to go through roughly 6-7 research papers per week, with usually 2 of those based on work done at HBCSE.

- Module 2: Student Conception, Assessments and concept inventories (research readings)
  - Student Conceptions
    - Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. Science Education, 66, pp. 211-227.
    - 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.
    - Pathare, S. R., & Pradhan, H. C. (2010). Students' misconceptions about heat transfer mechanisms and elementary kinetic theory. *Physics Education*, *45*(6), 629.
    - Subramaniam, K., & Padalkar, S. (2009). Visualisation and reasoning in explaining the phases of the moon. *International Journal of Science Education*, *31*(3), 395-417.
    - 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
    - Mahajan, B. S. & Chunawala, S. (1999). Indian secondary students' understanding of different aspects of health. International Journal of Science Education, 21(11), 1155-1168.
  - Student Assessments
    - Mintzes, J., Wandersee, J. & Novak, J. (2001) Assessing understanding in biology. Journal of Biological Education, 35:3, 118-124
    - De Champlain, A. F. (2010). A primer on classical test theory and item response theory for assessments in medical education. *Medical education*, *44*(1), 109-117.
  - Concept Inventories
    - Madsen, A., McKagan, S. B., & Sayre, E. C. (2017). Best practices for administering concept inventories. *The Physics Teacher*, *55*(9), 530-536.
    - Mashood, K. K., & Singh, V. A. (2015). Rotational kinematics of a rigid body about a fixed axis: development and analysis of an inventory. *European Journal of Physics*, *36*(4), 045020.
    - Hestenes, D., Wells, M., & Swackhamer, G. (1992). Force concept inventory. *The physics teacher*, *30*(3), 141-158.
    - Chastenay, P., & Riopel, M. (2020). Development and validation of the moon phases concept inventory for middle school. *Physical Review Physics Education Research*, *16*(2), 020107.

- Module 3: Education & Society, Out of Classroom Learning (research readings)
  - Out-of-Classroom Learning
    - 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.
    - 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.
    - Bose, A., & Subramaniam, K. (2011). Exploring school children's out of school mathematics. *The impact of teacher-led discussions on students' subsequent argumentative writing*.
    - Dutta, D., & Chandrasekharan, S. (2018). Doing to being: farming actions in a community coalesce into pro-environment motivations and values. *Environmental Education Research*, *24*(8), 1192-1210.
    - Bequette, J. W., & Bequette, M. B. (2012). A place for art and design education in the STEM conversation. *Art education*, *65*(2), 40-47.
    - Spendlove, D. (2008). Creativity in education: a review. Design and Technology Education: An International Journal, 10(2).
    - Dalvi, A., Muralidhar, A., Dolas, A., Shinde, R., & Chunawala, S. (2020). Designing and making roller coasters by Indian middle school students. *Proceedings of epiSTEME8*, 199201.
  - Socio-Scientific Issues
    - Sharma, A., & Chunawala, S. (2013). Students with disabilities and their aspirations in science. In *Proceedings epiSTEME 5: International Conference to Review Research on Science, Technology and Mathematics Education, Cinnamonteal: Homi Bhabha Centre for Science Education, TIFR* (pp. 74-80).
    - Raveendran, A., & Chunawala, S. (2015). Reproducing values: A feminist critique of a higher secondary biology textbook chapter on reproductive health. *Indian Journal of Gender Studies*, *22*(2), 194-218.
    - Raveendran, A., & Chunawala, S. (2015). Values in science: Making sense of biology doctoral students' critical examination of a deterministic claim in a media article. *Science Education*, *99*(4), 669-695.
    - Reiss, M. (2008). Should science educators deal with the science/religion issue? Studies in Science Education, 44 (2). pp. 157-186.
    - 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.
    - Mohite, S. (2014). Critical thinking on caste among school children in Maharashtra : Case study of two schools in Chiplun.

Economic and Political Weekly. Vol. XLIX, Issue 22.
        - K. Krishna (2010). Culture, state and girls: An educational perspective. Economic and Political Weekly, Vol 45, Issue No. 17, April 24, 2010.
    - Module 4: Teacher Development, Classroom interactions, Cognitive Modelling (research readings)
        - Classroom Interactions
            - 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.
            - Kumaravadivelu, B. (1999). Critical classroom discourse analysis. *TESOL quarterly*, *33*(3), 453-484.
            - Larson, J. (1995). Fatima's Rules and Other Elements of an Unintended Chemistry Curriculum. Paper presented at American Education Research Association (AERA), San Francisco.
            - Hiebert, J., & Wearne, D. (1993). Instructional tasks, classroom discourse, and students' learning in second-grade arithmetic. *American educational research journal*, *30*(2), 393-425.
            - 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.
            - Ramadas, J. & Kulkarni, V. (1982). Pupil participation and curriculum relevance, Journal of Research in Science Teaching, 19 (5), 357-365.
        - Teacher Development
            - 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.
            - 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.
            - 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.
            - 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.
            - Ursekar, C., & Naik, S. (2023). 'So basically I have to speak less and give students some freedom': how committing to a value influences a teacher's enactment of an inquiry-based science unit. *International Journal of Science Education*, 1-25.
            - Naik, S., & Ball, D. (2014). Professional development in a

laboratory setting examining evolution in teachers' questioning and participation. *Journal of Mathematics Education*, *7*(2), 40-54.

- Cognitive Modeling
  - Newen, A., Gallagher, S., & De Bruin, L. (2018). 4E cognition: Historical roots, key concepts, and central issues.
  - Wu, H. K., & Puntambekar, S. (2012). Pedagogical affordances of multiple external representations in scientific processes. *Journal of Science Education and Technology*, *21*, 754-767.
  - 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.
  - Chandrasekharan, S., & Nersessian, N. J. (2015). Building cognition: The construction of computational representations for scientific discovery. *Cognitive science*, *39*(8), 1727-1763.
  - Karnam, D., Agrawal, H., Parte, P., Ranjan, S., Borar, P., Kurup, P. P., ... & Chandrasekharan, S. (2021). Touchy feely vectors: A compensatory design approach to support model-based reasoning in developing country classrooms. *Journal of Computer Assisted Learning*, *37*(2), 446-474.

- **Weekly schedule of learning modules**
  - **Module 1**
    - Week 1: Why Education Research?, Research Question and Research Design
    - Week 2: Founding principles of educational studies
    - Week 3: What is qualitative research and quantitative research?
    - Week 4: Evaluation and Action Research, Publication of Research and Ethics
    - Week 5: Different dimensions of educational research (research reading)
  - **Module 2**
    - Week 6: Student Conceptions (research reading)
    - Week 7: Assessments & Concept Inventories (research reading)
  - **Module 3**
    - Week 8: Out of Classroom Learning (research reading)
    - Week 9: Education & Society (research reading)
  - **Module 4**
    - Week 10: Classroom Interactions (research readings)
    - Week 11: Teacher Development (research readings)
    - Week 12: Cognitive Modelling (research readings)