TEACHING MATHEMATICS IN WAYS THAT DISRUPT PATTERNS OF INEQUITY PREDOMINANT IN CLASSROOMS

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Historical and persistent marginalization and oppression permeate all aspects of contemporary life, including schooling. Institutional structures preserve and reinforce racialized and gendered norms, and exclusionary practices rooted in social and cultural status groups and identities. Change seems elusive. That teaching practice could be a force for change seems improbable to many. This talk will take up the question of whether and how teaching can contribute to disrupting racism, hate, inequity, and oppression and the experiences of those students who are persistently marginalized by instructional patterns and practices.

We will focus on the specific case of mathematics teaching and investigate patterns are produced and reproduced, minute to minute, day today, and week to week, inside the micro-relational and communicative work of teaching. We will ask explore how mathematics can be taught in ways that can change the nature of the experiences of children and affect their sense of identity, belonging, and success and will consider what it would take to make such instruction a reality inside of classrooms.

ALTRUISTIC USES OF SOCIO-SCIENTIFIC CAPITAL: A PRO-ECOJUSTICE PEDAGOGY

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Many societies around the world need to become more critical and activist, particularly in monitoring actions of powerful socio-economic entities — including governments, corporations, transnational trade organizations, think tanks, entertainment conglomerates, banks, individual financiers, etc. — and, where they perceive risks to wellbeing of individuals, societies and environments, develop and implement plans of action to try to bring about a better world. Key elements of power in this regard appear to be fields of science and technology (and, likely, other related fields, like engineering and mathematics) — which are essential instruments of wealth concentration and, associated with that, various personal, social and environmental harms. Science education in many places in the world has, for several decades, explored mandates for educating youth about relationships among fields of science and technology and societies and environments (STSE). While such education can contribute to development of critical and activist societies, there have been tendencies to emphasize controversies (e.g., as socio-scientific issues) and personal decision-making — which seem to limit critique and, moreover, socio-political actions. For about the last decade, however, the 'STEPWISE' framework has been used as a basis for curriculum development, field-testing and research in science and technology education to understand its potential for encouraging and enabling students to develop and implement informed plans of action to address problems they perceive. In this address, successes and struggles of this framework are reviewed — in light of cases of STEPWISE in practice and through various theoretical lenses. After particular focus on apparent opposition from neo-liberalism-informed networks of entities, possible approaches are considered for mobilizing perspectives and practices that might contribute to personal, social and environmental wellbeing.

MATHEMATICS AND MATERIAL MEDIATHE ROLE OF SENSE AND SENSATION IN MATHEMATICAL ACTIVITY

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This presentation focuses on the material dimensios of mathematical activity, exploring the aesthetic and embodied nature of mathematics. Theories of perception are central to embodied mathematics and play a pivotal role in both cognitive and neurological approaches to mathematics education research. This paper looks to contemporary philosophy for ways of understanding the *speculative* nature of perception. I use case studies of mathematical activity – both expert and novice – to track the embodied investment in inventive and speculative moments of mathematical behavior. Drawing principally on the philosophical insights of Michel Serres and Gilles Deleuze, this paper opens up discussions about the potentiality of the human body. Rather than study perception as the cognitive integration of multiple distinct sensory systems, my aim is to show how mathematical innovation emerges within learning environments as part of a *sensory milieu*, where learning is distributed across complex affective entanglements. Rather than center the rational Humanist subject as the synthesizer of sensory data, performing acts of discernment and judgment that collect and correlate disparate information, I explore how perception is dispersed across a material field of sensation. The consequences of such a theoretical shift are significant in that the body becomes open to new as yet unscripted future configurations, perhaps through technology 'augmentation' or simply through different forms of material media. The implications of this for how we work with dis/ability in mathematics classrooms are substantial, because it foregrounds and problematizes the relationship between sense (as meaning) and sense (as sensation). It also allows us to study the way that bodies are provisionally and temporarily enabled, directing our attention to the temporal contingency of dis/ability.

SOME OBSERVATIONS ON DISCIPLINE-BASED EDUCATIONAL RESEARCH IN SCIENCE, WITH PARTICULAR REFERENCE TO INDIA

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Discipline-based Educational Research (DBER) in college level science is getting increasing attention globally. In this talk, after some preliminary remarks on the nature and scope of DBER, we will illustrate the field by describing a few (from several available) pieces of notable DBER work emerging from the universities abroad. Some examples of DBER work carried out in this country will also be included in this very brief review. We will argue why this new field of inquiry is important for quality improvement of higher education in science in India and conclude with some suggestions for encouraging its growth here.

PROBLEM SOLVING: STRATEGIES, SOLUTIONS AND SUCCESSES

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The ability to solve unfamiliar and novel problem is an important graduate attribute. There has been much research that has explored the factors that affect student's success as problem solvers. This lecture reviews the literature on problem solving with a focus on strategies that aid success. It will then present some recent investigations into the differences between algorithmic, conceptual and open-ended problems and how strategies differ between novices, experts and between disciplines.

MATHEMATICS RESEARCH AND TEACHING: A TRANSCULTURAL HISTORY OF THE CIRCULATION OF MATHEMATICAL IDEAS BETWEEN INDIA AND EUROPE

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The relation between the history of scientific ideas and practices on the one hand and science education has been raised by science educators within the sphere of the pedagogy of science. The literature on the salience of history and philosophy of science to the pedagogy of science is voluminous. In the recent past, an additional aspect that has touched the interests of researchers and this has to do with what one might refer to as `problems in science teaching leading to research'. The claim is not that this is a new development for across the sciences and social sciences researchers have acknowledged their importance – from high school to post-graduate teaching. In this lecture I turn back, not so much to the history of sciences, but the history of mathematics to discuss a transcultural exchange between Indologists, practicing mathematicians and mathematics teachers from the first half of the nineteenth century. In other words, it explores the relationship between the world of research, the history of disciplines and teaching.

CATALYZING ADVANCES IN UNDERGRADUATE STEM EDUCATION

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We face profound global challenges, including providing adequate food, clean water, and energy; responding to changing weather patterns; supporting a growing world population; delivering health care; and addressing strife and inequalities. Understanding and addressing these challenges demands ingenuity, knowledge, wisdom, and compassion. Research on improving learning and building intrapersonal and interpersonal competencies can be used to prepare STEM graduates to address these complex, multidimensional problems. These graduates need both deep disciplinary understanding and the capacity to work synergistically across domains extending beyond science, mathematics, and engineering. Discipline-based education research (DBER) has contributed substantially in the areas of conceptual understanding, conceptual change, and developing expertise in problem solving, using representations, and instructional strategies. Effective instruction includes a range of well-implemented, research-based approaches that actively engage students in their own learning. These

strategies are more effective in enhancing learning than traditional lecture. Learning through undergraduate research and developing the skills needed to contribute to a team also prepare students for productive careers. Competencies beyond cognitive skills can boost students' persistence and completion. A new study from the U.S. National Academies for Science, Engineering, and Medicine concludes that brief, low-cost interventions can support a student's sense of belonging, belief that her intelligence and ability to learn is malleable, not fixed (growth mindset), and perception that her academic work is leading to a desired end. As a result, these students are more likely to complete their degrees and lead financially sound and healthier lives. Together, the growing body of evidence on STEM learning provides guidance for redesigning the undergraduate experience to support students' success as learners and as adaptive contributors in the workforce.

INTERACTIVE LECTURE DEMONSTRATIONS: AN EFFECTIVE ACTIVE LEARNING STRATEGY FOR LECTURE

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The results of physics education research and the availability of computer-based tools have led to the development of active learning materials to improve conceptual learning in the introductory physics course. These include hands-on, student-centered laboratory curricula like *Real Time Physics (RTP)* (Sokoloff, Thornton& Laws, 2007), and lecture materials like *Interactive Lecture Demonstrations (ILDs)* (Sokoloff, & Thornton, 1997; Sokoloff, 2016). The success of these materials is based on (1) engagement of students in the learning process, and (2) clear and understandable presentation of real observations of the physical world. Student learning assessment using conceptual evaluations has played a large role in the development and validation of these approaches. *ILDs* in most areas of physics have been published by John Wiley and Sons in the book, *Interactive Lecture Demonstrations* (Sokoloff, & Thornton, 2004). Examples of *ILDs* in different areas of physics, and the eight-step *ILD* procedure will be demonstrated through audience participation. Uses of *ILDs* to create an active learning environment, and results of studies on the effectiveness of *ILDs* will also be presented.

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AN EMPIRICAL APPROACH TO CURRICULUM DEVELOPMENT

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What one should include in the science curriculum at various stages from school through college has long been of concern to educators the world over. Whenever deemed necessary, changes in curricula have generally been brought about incrementally, based on feedback mechanisms that give information about previous ones. In India, the content is generally arrived at through consultation with scientists and science education experts. Our approach to curriculum development at the middle school level departs from this practice of incremental changes. We undertook an empirical study, which was longitudinal in nature, wherein material was developed through intensive classroom research with a cohort of students as they progressed from one grade to the next. This research investigated students' cognitive readiness at any given grade for specific concepts in science and identified their difficulties with them. It helped explore and build conceptual trajectories, often non canonical ones that were highly effective. This is particularly important in the middle school years, when students are introduced to foundational concepts in science which form the building blocks of much that will follow in subsequent years. This exercise led to a coherent, inquiry oriented curriculum, and at the same time provided insights into effective pedagogy, another area of intense research in science education. In this talk, I will discuss the methods we adopted, the considerations that informed the content and its transaction, and, finally, the challenges encountered.