Homi Bhabha Centre for Science Education,

Tata Institute of Fundamental Research

Annual Research Meet

October 12-13, 2015

Introduction

Annual Research Meet (ARM), as we know, is a platform where researchers at HBCSE get an opportunity present their research and get newer perspectives for their research through the insights of their peers.

ARM 2015, would be held on 12th and 13th October. 16 researchers among research scholars, PhD scholars, faculty and scientific staff would be presenting their research work in the field of education in this 2 day meet. This meet would give each one of us an opportunity to understand each other's research and also give insights into their work.

Looking forward to everyone joining the meet and making it a huge success.

Homi Bhabha Center For Science Education

(TIFR)

ANNUAL RESEARCH MEET – 2015

Schedule

12/10/2015	
Monday	
Time Slots	Presentation by
10:00-10:15	Welcome
10:15-11:00	Prajakt Pande
11:00-11:30	Rossi D'souza
11:30-11:50	TEA BREAK
11:50-12:30	Karen Haydock

13/10/2015	
Tuesday	
Time Slots	Presentation by
10:00-10:30	Rosemary V.
10:30- 11:15	Himanshu S.
11:15-11:30	TEA BREAK
11:30 -12:00	Geetanjali Date
12:00- 12:30	Vinod Sonawane

12:30-13:10	Amit Sharma
13:10-14:00	LUNCH
14:00-14:45	Jeenath Rahaman
14:45-15:30	Durga Prasad
15:30-16:15	Gurinder Singh
16:15-16:30	Closing
16:30-17:00	SNACKS

12:30-13:15	V.D.Lale
13:15-14:15	LUNCH
14:15-14:45	TBA
14:45-15:15	Deborah Dutta
15:15-15:45	Charudatta N.
15:45-16:15	Rafikh Shaikh
16:15-16:30	Closing
16:30-17:00	SNACKS

Presentations

1. **How Do Experts And Novices Navigate Chemical Representations : An Eye Tracking Investigation**

   - Prajakt Pande

2. **Concepts As Processes**

   - Rossi D'Souza

3. **The Balance of Nature**

   - Karen Haydock

4. **Experimentation In Physics**

   - Vinod Kumar Sonawane

5. **Construction of Area Concept In A Classroom**

   - Jeenath Rahaman

6. **Nature Of Trigonometric Knowledge And Representation**

   - DurgaPrasad Karnam

7. **Exploring The Relationship Between Observations And Question Asking Among Middle School Students**

   - Gurinder Singh

8. **Design Process Of A Formally Trained Engineer Working At The Grassroots**

   - Geetanjali Date

9. **Transformation Agenda In Science Education: Stories And Questions From The Field**

   - Himanshu Srivastava

How Do Experts And Novices Navigate Chemical Representations : An Eye Tracking Investigation

Prajakt Pande

In this study, chemistry professors (experts) & undergrads (novices) view & categorize multiple external representations (MERs) of five different chemical reactions. Using eye-tracking, we capture fine-grain data about participants' gaze patterns while they view given MERs, which we then correlate with the quality of categories they generate as well as justifications they provide for those categories. The professors tend to form chemically meaningful relationships between MERs than do undergrads. Eye-tracking data reveal significant differences between the two groups, in navigating chemical equations.

Key Words: *Cognitive Studies of Science Learning, Chemistry Education*

Discussant: Dr. Ankush Gupta

Concepts As Processes

Rossi D'Souza

The teaching of mathematics as a set of fixed concepts and procedures perpetuates the idea that mathematics is a fixed thing to be learned rather than a process to be practiced and experienced. Historically, mathematicians have engaged in the process of discovering patterns, proving the existence or certain properties of such patterns, developing models, creating definitions and theorems on the basis of which they would communicate ideas and develop more definitions, theorems, etc. Engaging students with the process of doing mathematics serves many purposes. For example, learners would be trained in process of doing mathematics while simultaneously learning by using some already developed mathematical ideas. Also it is more fulfilling when the learner discovers a novel or discovered pattern, rather than if someone else with certain abilities discovers a pattern and asks a student with different abilities to arrive at the same pattern. In addition, they would contribute even to the development of the discipline of mathematics. In my ARM talk, I present observations that emerged from my mathematics learning sessions at a learning centre wherein children would be engaged in doing mathematics and presenting novel mathematical findings and also arriving at some consensus with regard to, say, defining concepts like odd and even numbers. They would also explore the history of the need to conceptualize negative numbers. By engaging with their life experiences and taking charge of deciding how a concept should be defined (rather than how it "is" defined), learners would experience ownership of their constructed mathematics knowledge.

Key words: *Education Research, Nature of mathematics*

The Balance of Nature

Karen Haydock

Is there a 'Balance of Nature'? In this lecture, I will try to convince you that there is not. The evidence will be from the fields of ecology and biology. I will also discuss how and why some biology teachers and others nevertheless cling to a belief in a balance of nature, and how such a belief is detrimental to understanding and solving the environmental crisis which we face.

Key Words: *History and Philosophy of Science, Cognitive Studies of Science Learning, Science, Technology and Society, Education Research*

Experimentation In Physics

Vinod Kumar Sonawane

Children learn many things during the school age. The major source of information and knowledge is a text book. Everyone gets formally educated and completes school education performing very few experiments. Laboratory component is the most neglected component in the average school.

In 1820, Hans Christian Oersted performed an important experiment which showed that there is a connection between electricity and magnetism.

Key Words: History and Philosophy of Science, Physics Education

Construction of Area Concept In A Classroom

Jeenath Rahaman

In this article I will analyse four classroom episodes of argumentation among students involving aspects of the concept of area. Such episodes of argumentation among the students occurred when there were contending solutions for the same problem. The analysis will elaborate on the process of construction of the area concept in the classroom by focusing on two major aspects of the classroom interaction. The first is the structure of students' argumentation, how they defend their claim and what warrant they use. I will aim at showing that the ideas of unit covering of area and of structuring such coverings forms a sound basis of shared understanding that supports students' arguments. Numerical aspects of area understanding are constructed on the basis of the spatial unit structuring. The second focus of the analysis is the various numerical aspects associated with the area concept (e.g., decimal and fraction representation, lxb formula) and the constant tension faced by students in the movement between spatial and numerical representation. The present study was part of a vacation camp, conducted in a BMC school with around 30 students from 6th and 7th grade for twelve days. Keywords: unit, area-concept, argumentation, spatial, numerical.

Key Words: *Education Research, Nature of mathematics*

Discussant: Shamin Padalkar

Nature Of Trigonometric Knowledge And Representation

DurgaPrasad Karnam

Nature of Trigonometric Knowledge and Representations
Trigonometry is introduced to students during the later parts of high school, as part of Mathematics, along with many applications in Physics. It is considered a difficult concept for students to understand, as trigonometry combines cognitive (internal) operations and symbolic(external) manipulations in complex ways. Here, I take three canonical cases: i) heights and distances (ratios in triangles) ii) periodic systems (represented as sinusoidal systems) and iii) componentization of vector quantities (breaking vectors in multidimensional spaces into components), all of which appear in the curriculum of high school and pre-college students (9th,10th, 11th and 12th grade). Students engaging with these cases face many problems in making sense of the symbolic and cognitive manipulations, possibly because the relations between these operations are not clear. The talk shall make an attempt to make explicit the jumps in thinking, across symbolic spaces that are needed in each of the cases. Connecting these jumps with the problems faced by students could provide insights into the nature of Trigonometric knowledge and how it is related to the different representations, and operations on them. I propose, using examples, that new media intervention, informed by the connection between trigonometric knowledge and representations could help in devising scaffolding tools that allow students to understand trigonometry better.

Key Words: Cognitive Studies of Science Learning, Structure and Dynamics of Knowledge

Discussant: Dr. K Ravi Subramaniam

Exploring The Relationship Between Observations And Question Asking Among Middle School Students

Gurinder Singh

In this study we present our analysis of questioning among class VIII students upon seeing a variegated leaves plant. Participants were 11 students of an urban government aided school of Mumbai with 6 girls and 5 boys. Data was collected in the form of audio-video recordings, photographs, students' written work and researchers' observations and notes. Through this study we are trying to understand the role of observations in question asking and role of questions in making observations among students by looking at the detailed transcriptions of conversations of each of the six girls as they observed the plant.

Key Words: *Structure and Dynamics of Knowledge*

Discussant: Aisha Kawalkar

Design Process Of A Formally Trained Engineer Working At The Grassroots

Geetanjali Date

Based on the research design presented in my PhD proposal, I present a preliminary analysis of data from the micro-hydro turbine design process of a formally trained engineering professional. The data is collected through interviews, field observation, and secondary data sources. Using a typical model of engineering design process as a lens, I look at the nature of the design process of the formally trained engineer, particularly exploring how the context i.e. the environmental and social factors feed into the design, and whether these also shape the detailed design process later if at all. This is work in progress.

Key Words: *Engineering Education (STEM)*

Discussant: Aditi Kotiyal, Doctoral student, IITB and Prof. K. Subramaniam, HBCSE

Advisor: Dr. Sanjay Chandrasekharan

Transformation Agenda In Science Education: Stories And Questions From The Field

Himanshu Srivastava

As part of my main study, I am exploring possibilities of social transformation through science education in the context of waste. Mapping students' knowledge base and their values related to waste, consumption, nature, development, health and hygiene is as crucial as the critical analysis of their educational experience to locate gaps and work out a solution.

In order to get a sense of the range of ideas regarding waste and related concepts prevailing among 14-16 year olds, a weeklong workshop was organized with eight students who were attending classes in a tuition centre in Bainganwadi - the primary site for my field work. Conducting a workshop there provided a good opportunity to get a little closer to the community who lives in the close vicinity of perhaps the largest dumping ground in the country. While in the workshop the focus was on eliciting students' ideas regarding waste, the cycle of waste and its political economy, I also managed to interact with a few of them on a personal basis and understand their day-to-day struggles and their aspirations.

In this talk, I will discuss preliminary reflections on the data from the out-of-school workshop and personal interactions with five participant students. Based on their lived experiences, while all of them had lot of stories to share about toilet facility, situation of drinking water and health, increasing violence on streets and so on, their conceptual understanding of various topics in science seemed to be far from expectation. For example, their understanding of materials or hygiene and the associated diseases was found to be inadequate.

The experiences so far in the field have also left me with another set of questions like what does change / transformation mean for people of M (East) ward and what can be done through science education to enhance critical consciousness among students and get them to think and act toward bringing out 'change' (at personal level as well as in the community) without devaluing their aspirations for a more comfortable life. As the struggle with these big questions continues, what seems to be a possible roadmap for the remaining journey will also be outlined.

Key Words: *Science, Technology and Society* **Discussant:** Dr. Sanjay Chandrasekharan

Changing Portrayals Of Farmers And Agriculture: The Case Of SCERT (Kerala) Textbooks

Rosemary Varkey M.

How do school textbooks portray farmers and agriculture? This is one of the questions that I'm pursuing as part of the research project to understand the relationships between agriculture, farmers' and scientific methods and education. To answer this, I analyzed science textbooks of standards III to VIII of SCERT, Kerala including some of the old textbooks. Preliminary analysis shows that the shifts in public debates on agriculture and farmers get reflected in curriculum frameworks that guide textbook writing workshops and subsequently in textbooks.

The nature of these shifts in the content, focus, values and presentation of textbooks shows a spiral of movements and countermovements. Though the content of the textbooks change as a result of the changes in the public debate, textbooks still serve as an influential change agent since the vast majority of people including students embrace or learn about alternatives or changes only if others lead them by example. Comparison of an old textbook of 1970's with the most recent textbook and discussion with some farmers indicate that the nature of these changes do follow the pattern mentioned above.

Key Words: *Science, Technology and Society*

Science learning and visualization: How students with and without vision visualize atomic structure

Amit Sharma

Knowledge of science and technology is a must for optimal social participation of citizens. However, students with visual impairments (SVI) often are at a disadvantage while learning science and technology due to the excessive use of the visual mode of communication in teaching (Kumar, Ramaswami & Stefanich, 2001; Fraser & Maguvhe, 2008). Visualization does not depend solely on vision (Figueiras & Arcavi, 2012) rather it is cognitive and can be aided by explanatory verbal descriptions, tactile and other representations. Aim: To understand and enhance visualization of SVI in the context of school science learning. Methodology: This was a qualitative study that used science activities related to teaching atoms and how different scientific atomic models are perceived by students. It was conducted with two different groups of students in different educational settings. The first group was an inclusive setting of 4-5 students (two students had no vision, one low vision and two had normal vision) and the other was a special educational setting (3-5 students with no vision). All interactions were video recorded and transcribed for analysis. Findings: Verbal descriptions, tactile perceptions, 3 dimensional models and objects as well as diagrams (learning through diagrams and drawing them) were effective in providing learning experiences to SVI. Students in inclusive settings benefited through collaboration. Relevance: The study highlights the processes through which SVI visualize and learn science. It suggests that changes in educational methodologies may benefit SVI and also enrich the field of science by providing new dimensions of perceptions.

Key Words: *Cognitive Studies of Science Learning*

Discussant: Prof. Jayashree Ramadas

How To Generate Environment-Oriented Actions And Motivation: Urban Farming As A Possible Method

Deborah Dutta

Emerging ecological crises need urgent action, and motivating students to engage in pro-environment actions is an important aim of environment education (EE). However, EE often fails in nurturing pro-environment behaviour. I argue that the current structure of EE does not address the close and mutually supporting interaction between motivation and action, and this is one reason it falls short of creating a 'transformative' approach towards the environment in students. This transformation requires creating a positive feedback loop between motivation and action. In contrast to EE, there are educational initiatives focused on actions in the world, primarily farming, such as Nai Talim, Green Bronx Machine and Guerilla Gardeners' Movement which have been successful in promoting pro-environmental behaviour and motivation. However, these projects are driven by environmental activism or nature-oriented philosophical positions, and as such, they have not sought to capture the design principles underlying these interventions. Making explicit the principles underlying these designs is a necessary step for developing similar educational interventions and policy initiatives centred on actions in the world, but at a large scale.

My project seeks to capture the central design principles underlying these approaches, using urban farming as a micro-level replication of such initiatives. I will explore how pro-environmental behaviour is promoted by urban farming actions, and whether/how such actions motivate students to engage in further environment-oriented actions. I propose to capture in-depth case studies of individuals engaged in urban farming, to examine whether and how this activity leads to pro-environmental attitude and behaviour. The proposed findings would support the development of new EE policies that emphasize

the primacy of community level close interactions with the world.

Key Words: *Science, Technology and Society, Environment Education*

Discussant: Ankush Gupta

Making A Point With Lines : Comics In Education

Charudatta Navare

Spoken/Visual/Sign languages are representational systems that differ in the kinds of references they use to express concepts. Yet, cultural perception of these varies greatly. Drawing is often looked at as an art, rather than language. Perceptual viewpoint of drawing holds that you draw what you see, rather than what you want to represent/express. This framework leads to emphasis against imitation of drawings, prohibiting the acquisition of graphic schemas. Cultural differences in drawing skill could be originating from the beliefs surrounding drawing. Cognitive model of drawing as a language is discussed, which is antithetical to the perceptual viewpoint.

Implications of this model for creation and perception of visual languages are vital for education/outreach. Comics can be viewed as serious literature, a tool for social commentary, and as a medium for education/outreach. Subjective experience of reading comics doesn’t necessarily inform how actual comprehension of visual language works. This creates a need for better theory of comics and of comprehension of visual languages. Path towards building and refining the comic theory is discussed.

Key Words: *Cognitive Studies of Science Learning, Education Research*

Learning In A Shared Space: A Study Using Instant Messaging Environment

Rafikh Shaikh

We investigate the role of shared screen (computer) in teaching and learning of arithmetic in a technology aided classroom. About 44 students from a municipality school in Mumbai participated in the study. They were divided into two groups, one group played a game (Chatstudio Self) with computers and the other group played the number game (Chatstudio Group) with each other facilitated by the computer. Pre and post tests were conducted to test proficiency in arithmetic. Computer logs, audio logs and field notes were collected during intervention. We will present some preliminary results from our data analysis and then open rest of the data to audience to get comments and suggestions for further analysis.

Key Words: *Science, Technology and Society, History and Philosophy of Science, Structure and Dynamics of Knowledge*

Discussant: Dr. Sanjay Chandrasekharan

Development of Kumar Vishwakosh: A Learning Experience

Vijay D. Lale and H. C. Pradhan

The Homi Bhabha Centre for Science Education (HBCSE) and Maharashtra Rajya Vishwakosh Nirmiti Mandal, a statutory body, Govt. of Maharashtra is working together to develop Kumar Vishwakosh (an encyclopedia for age group 12-21) in Marathi. HBCSE has formally accepted to develop an encyclopedia on 'Biology and Environment' and has produced vol. 1 & 2 under this project. It is a pioneering work of producing encyclopedia for young students and it will help to produce other encyclopedia for other subjects, too. A nature of work and learning experiences of this project will be discussed.

Key Words: *Education Research, Science, Technology and Society*