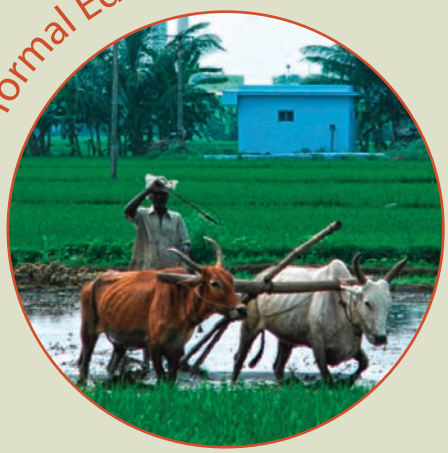
Primary and Secondary Education

Higher Secondary and Tertiary Education

Teacher Education

Non-formal Education



ARM 2013

ANNUAL RESEARCH MEET

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September 23–25

Homi Bhabha Centre for Science Education
Tata institute of Fundamental Research

Abstracts

Learning with multiple representations in science, mathematics and engineering: A brief review of theoretical and empirical accounts

Prajakt Pande

Multiple representations are central to science, mathematics, engineering and technology learning and practice. Expertise in these fields requires representational competence (RC), which is defined as the ability to simultaneously process and integrate multiple representations in that domain. A major strand of research in science, technology, engineering and mathematics education attributes students' difficulties in learning to difficulty in understanding multiple representations and interlinking the information they convey.

We review the literature on learning with multiple representations, as well as representational competence, in chemistry, biology, physics, mathematics and engineering, focusing on the important theoretical accounts and empirical studies in each of these domains. We then develop a comprehensive perspective of the RC problem, by capturing: i) the significant similarities and differences in RC between and across disciplines ii) how the nature of problems in each discipline is related to the nature of multiple representations used in that discipline and iii) how learning difficulty in each discipline is related to the nature of multiple representations.

Keywords: *multiple representations, representational competence (RC)*
Guide: Sanjay Chandrasekharan
Discussant: Jayashree Ramadas

Notes

Understanding thermal equilibrium through activities

Shirish Pathare

Thermal equilibrium explains aspects of heat energy transfer between objects of different temperatures. It is an important concept in elementary thermodynamics with several applications. Essentially, objects in the same environment eventually attain the same temperature as the environment. This concept of thermal equilibrium is generally introduced at the first year of undergraduate education. It is important and essential for the students to understand that the net heat flow between the systems becomes zero when they attain thermal equilibrium.

Thus, students' understanding of thermal equilibrium was selected as one of the areas for study and the data for the same was collected through a questionnaire. The total sample consisted of 300 first year and second year undergraduate students from different colleges in India.

One of the prominent observations from the analysis of the questionnaire was: "Students do not believe that objects in thermal contact will tend towards thermal equilibrium and thus reach same temperature, but relate the final temperature to the material of the object under consideration."

Thus to address the students alternative conceptions and to enhance understanding of thermal equilibrium, different activities are developed and pilot tested with second year undergraduate students. The current presentation describes four such activities. They are related to:

1 thermal equilibrium between copper and wooden cubes

2 liquid flow analogy to understand thermal equilibrium

3 heat flow model to understand thermal equilibrium

4 liquid flow model of thermal equilibrium between copper and wooden cubes.

In my presentation, I will also give a brief description of the study conducted with second year undergraduate students.

Keywords: *thermal equilibrium, alternate conceptions, undergraduate*
Guide: Savita Ladage
Discussant: Anwesh Mazumdar

Notes

Measure concept-mapping, not concept-maps: Procedural analysis elucidates stages in students' understanding of biology concepts

Anveshna Srivastava

I will present an overview of a pilot study where we explored the way undergraduate biology students organized their knowledge of the DNA structure.

12 students were asked, individually, to build a concept map of the DNA structure, using 37 concept cards. The manipulable physical elements, relating to concept (cardboard cards), linking (chart paper arrows) and phrases (stick-it notes), allowed us to track individual events during the map-building process. I will present results from a microgenetic analysis of the data, where we analysed the structure of the generated concept-maps, and also the process by which the concept-maps were generated. I will discuss some possible pedagogical interventions based on results from the study, and outline how I plan to build the next phase of studies on these results.

Keywords: *DNA structure, Physical manipulation, Concept mapping, Microgenetic Study, Structural Analysis, Procedural Analysis*
Guide: Sanjay Chandrasekharan
Discussant: Jayashree Ramadas

Notes

Understanding diagrams for inclusion

Amit Sharma

Today, societies are in a transitional stage towards educational inclusion and hence there is a dire need to develop and study effective pedagogies for inclusive science education (Sharma & Chunawala, 2013). Diagrams are important tools for understanding life sciences as the visualization initiated by them "makes complex information accessible and cognitively tractable" (Uttal & Doherty, 2008) to learners. Hill (1995) in a study reports about how raised line diagrams can be used for students with visual impairments (SVI) to give nearly full access to diagrammatic aspects of science and raise the quality of science education. The haptic perception through raised lines and the visual perception through the use of colors give full opportunity for visualization to students with or without vision. Use of such multi sensory modality may produce a better learning pedagogy for including the students that use different modes of perception in the same science classroom.

This study tries to understand the processes involved in the use of raised line diagrams in inclusive classroom in an unguided, collaborative learning situation and; the effectiveness of such diagrams in same situation for student with visual impairment in learning and transfer of information.

Keywords: *qualitative understanding, collaborative learning, inclusion, diagrams*
Guide: Sugra Chunawala
Discussant: Nagarjuna, G.

Notes

Trends in concept mapping research: A two decade review of literature

Meena Kharatmal

The present study is an exploration of research trends in concept mapping in science education through content analysis of research articles published in journals. The review is from journals in science education - International Journal of Science Education (IJSE), Journal of Research in Science Teaching (JRST), Science Education (SE), Journal of Biological Education (JBE), covering the two decades from 1990 to 2010.

The study investigates research areas that have been widely represented, the current research trends, domain of subject. The widely followed research trends of concept mapping have been: *(i) students' understanding, meaningful learning; (ii) knowledge re-structuring; (iii) novice-expert studies; (iv) knowledge representation; (v) learning of science; (vi) assessment, reliability, validity.* The study will also highlight the current direction of research trends in concept mapping. In the process, a bibliography of all the articles spanning the two decade has been generated.

Keywords: *concept mapping, journal, science education, meaningful learning, knowledge re-structuring, knowledge representation, novice-expert studies, assessment*
Guide: Nagarjuna, G
Discussant: Karen Haydock.

Notes

Farmers beliefs Associated with Cultivation: Case studies

Rosemary Varkey

Agriculture and allied sectors constitute the livelihood of around 70% of India's population. NCF-2005 recommends that "engaging with local knowledge/indigenous practices in the local area, and relating these to school knowledge wherever possible," should be a component in curriculum planning. However, our education system still has not given due recognition to farmers' traditional knowledge. As a result, students coming from agricultural backgrounds may become alienated from science.

In order to clarify ways to include farmers and their traditional knowledge in education, we need to find out the nature of their knowledge and practices. As a first step, we are trying to shed some light on their beliefs associated with cultivation through semi-structured interviews done with five farmers in Kottayam, Kerala.

If we consider science as a method, we can try to identify some of the processes which may be included in this method. We can then investigate the similarities or differences in the processes of traditional and scientific methods. Based on this understanding, we may then analyze whether farmers are doing such processes, to what extent they are doing them, and how intentionally and for what reasons and purposes they are doing them. This will give us some insight into farmers beliefs associated with cultivation.

Keywords: *traditional knowledge, farmers, agriculture, case study*
Guide: Karen Haydock
Discussant: Sanjay Chandrasekharan

Notes

Knowledge of contexts for the teaching of mathematics

K. Subramaniam

Since Lee Shulmans writings in the 1980s, education researchers have recognized the importance of subject matter knowledge for teaching. It is now widely believed that there is a domain of content knowledge that is specialized for the work of teaching. Several researchers, following the pioneering work of Deborah Ball and her collaborators, have attempted to characterize the specialized knowledge needed for teaching in the subject of school mathematics. In this presentation, I shall argue that knowledge of contexts is a distinct and important component of such knowledge. Drawing on the research and intervention work done by the mathematics education group at HBCSE, I will discuss examples of context knowledge from a variety of topic domains. I will present arguments for why such knowledge may be important, even necessary, for the effective teaching of mathematics.

Keywords: *Mathematics education, context, content knowledge*

Notes

Making meaning of teachers' knowledge of students' mathematical thinking: Towards an analytical framework

Shikha Takker

The efforts focusing teacher development often emphasize prior preparation of a teacher for classroom teaching or highlight the necessity of reflecting on the teaching episodes (experience of other teachers). However, the dialectic between efforts made by a teacher to teach a mathematical concept to learners of diverse needs and students thinking that shapes the classroom learning is often not deliberated upon. It is important to engage with teacher knowledge gained from practice or experience and build teacher learning on that. This study investigates teaching practices of experienced mathematics teachers to explore ways in which their knowledge of students (mathematical) thinking gets operationalised in teaching. Diverse data sources are employed to unveil interesting facets of teacher practice in situ. In this paper, I present and elaborate on the process of developing an analytical framework to make sense of teacher knowledge and response to students thinking in practice.

Keywords: *mathematics education, teacher development, mathematical thinking*
Guide: K. Subramaniam
Discussant: Jyotsna Vijaypurkar

Notes

Indian teachers' views about & practice of school projects

Saurav Shome

The study was part of a series of teacher workshops conducted to develop project-based learning (PBL) module in collaboration with middle and high school level teachers. The study explores teachers' views about projects and ideas on their project practices using a questionnaire tool. The tool was administered to thirty four participants including teachers and teacher educators, who had agreed to participate in a series of workshops on PBL. The responses to 8 open-ended questions and one question with 24 statements on Likert scale, were analysed for the study. It was found that in general teachers associate projects with positive feelings and better learning. It was also found from the teachers' reported project practice that stated learning goals did not align with the tasks given and assessment conducted. Besides, the stated advantages were not supported by evidences from assessment. The study was meant to provide initial state inputs for the planned series of workshops on PBL, and it was noted that the projects reported by most teachers includes very few of the essential project criteria delineated in the PBL literature (Thomas, 2000).

Keywords: *project, teacher views, teacher professional development, project-based learning*
Guide: Chitra Natarajan
Discussant: K. Subramaniam

Notes

Exploring Network Model: Area-measuremt Concept in Classroom

Jeenath Rahaman

In the study presented here we are trying to explore the network model of area-measurement concept in a classroom setting. Area measurement connects and enriches two critical domains namely geometry and number. However, building the conceptual connection between these two domains is full of challenges. Area can be seen as an important entry point to the deep connection between various numeric and geometric structures. Therefore, we are trying to reformulate the area concept as a network requiring an integration of various other spatial and numerical concepts. Using this theoretical model, we are trying to develop a spiral of tasks which can address different aspects of the area concept. And then trying out these tasks with students in a classroom setting to explore whether and how they can connect these different individual concepts in the network.

Here in each lesson used in each individual class, we tried to develop an integration of different subconcepts involved in the understanding of area-measurement, and have found that their exploration in class enriches this network of concepts by bringing many more concepts from their own context, presenting varied ways of thinking about a problem.

Keywords: *area measurement, network model, integration of concepts, manipulation, multiple units*
Guide: K.Subramaniam
Discussant: Jyotsna Vijaypurkar

Notes

Learning to change the world: Social impact of OLPC

Rafikh Shaikh

This is a book written by Walter Bender, Charles Kane, Jody Conrish, and Neal Donahule about their experience with OLPC (one laptop per child). The book narrates story of OLPC right from its genesis until 2012.

OLPC was started with the mission to empower children in developing countries to learn. In order to do that, the organisation was to design a laptop with novel hardware and software. A laptop which would become 'thing to think with' for children living in developing countries, a laptop which will survive the harsh conditions of those countries (temperature, no electricity or scarce electricity, dust, rough handling by children, no internet connectivity, etc). A laptop which will be a manifestation of Papert's 'children's machine' which help children learn constructionist way.

This book is the story of how/whether OLPC achieved above stated goal, what challenges they faced as an non-profit organization and how they tackled them. The story about their successes and failures.

Keywords: *one laptop per child, thing to think with, constructionism*
Guide: Nagarjuna, G.
Discussant: Karen Haydock

Notes

The state of experimental activities in schools

Gurinder Singh

The laboratory has been given a central and discrete role in science education, and science educators have suggested that there are rich benefits of learning through laboratory activities. (Hofstein & Lunetta, 1982). Science curriculum is thought to be very 'dry' if there are no experiments for students to perform. It is unthinkable to have Science curriculum devoid of practical component. But many science educators have questioned the contribution of the laboratory in teaching and learning science. Hodson (1991) claims that: 'as practised in many countries, it is ill-conceived, confused and unproductive'.

Since the inclusion of Science as a core subject at middle and high school level in India, stress has been given to make laboratory as distinct part of the subject. But there has not been much sucess in making laboratory work effective upto high school level. Lack of infrastructure is cited as one of the main reasons for neglect of laboratory work in schools. Science educators and policy makers have argued for designing low cost experiments (NCERT, 2006), but no efforts have been made to introduce low cost experiments in the curriculum of secondary and higher secondary science.

In this study we tried to mainly look into the existing strategies of laboratory instruction and the assessment of laboratory work at 9th grade in CBSE schools. Students and teachers' perceptions about laboratory work were also investigated by the researchers. Data was collected through interviews and questionnaires. Most of the students said that they enjoy doing practicals and want more time should be given for practical work than theory. Analysis of the data shows that usually cook-book approach is followed in laboratory where teacher describes each and every aspect of the experiment in detail before students perform on their own. In such a situation students participation becomes passive and they hardly get a chance to think on their own and construct their knowledge.

Keywords: *laboratory instruction, thinking abilities, experimental skills, cook-book, assessment of laboratory work, constructivist approach*
Guide: Rajesh B. Khaparde
Discussant: Karen Haydock

Notes

Cognition, Science education, and Models

Sanjay Chandrasekharan

I will first outline how cognitive science relates to other sciences and science education research. I will then present an overview of the research projects I will be working on in the next four years.

Keywords: *cognition, science education, models*

Notes

Reproducing values: Examining how the higher secondary science curriculum and students discuss reproductive technologies from a critical scientific literacy perspective

Aswathy Raveendran

The paper will be an exploration, from a critical scientific literacy perspective, of how the national higher secondary school biology curriculum engages with the the idea of reproductive health. Critical Scientific Literacy advocates like Hodson (2003) envision a politicized science curriculum that seeks to foster social justice concerns in the students. Such a curriculum recognizes that social and political values underpin scientific and technological development and will seek to make explicit these values to students.

What I attempt, is a content analysis of the class XII NCERT chapter on reproductive health which discusses a range of technologies that serve to facilitate population control as well as fertility enhancement. The analysis is based on the framework that sees the 'knowledge' that is selected and organized in textbooks as reflecting certain ideologies (Apple,1990). I will attempt to place these technologies in their social and historical context and raise questions on why they are selected and discussed in the context of reproductive health, what aspects pertaining to them are foregrounded and what is silenced. The critique will raise questions on the status of Science-Technology-Society issues in the higher secondary science curriculum.

Keywords: *critical scientific literacy, textbook analysis, higher secondary, biology curriculum, socio-scientific issues, values in science*
Guide: Sugra I. Chunawala
Discussant: Karen Haydock

Notes

Exploring the phenomena of electromagnetic induction

Amit Dhakulkar

Some very simple and interesting manifestations of the phenomenon of electromagnetic induction can be used as qualitative classroom demonstrations. Many of these manifestations can be built as toys easily and at very low (or no) cost. But can these demonstrations be used for making quantitative measurements? We present here an inquiry on exploring one such toy by students. Students made hypothesis about effect of changing various parameters on the induced voltage in the coil used in the toy. These parameters were manipulated by the students and the results were recorded and plotted to check the correctness of the hypothesis. To assist in the collecting of data, the expEYES kit was used in the experiments. The entire exercise led to experimental basis of many statements about the laws of electromagnetic induction. This task also establishes the coil as an exemplar model systems in which change in any parameter is quantifiable and open to analysis.

Keywords: *electromagnetic induction, expEYES, quantitative measurement*
Guide: Nagarjuna G.
Discussant: Karen Haydock

Notes

Exploring knowledge generating practices in a laboratory environment

Shraddha Ghumre

In this narrative of a very preliminary analysis of an undergraduate research laboratory, based on simple model systems, we are trying to construct an account of how scientific knowledge is produced in such settings. We intend to eventually illustrate the myriad of resources that such a setting can offer towards understanding scientific problem-solving practices in general and model based reasoning in particular as embedded in the social and material environments.

We are trying to base our work on Nersessian's integrative account of knowledge producing practices by studying situated cognitive practices in distributed systems.

We will try to establish that the laboratory is an evolving system where cognition is distributed over the social and material environment in the lab. We are using a distributed cognition model to understand the nature of representations evoked and constructed by students during their research investigation and their associated reasoning processes. We will try to describe how each research problem in the laboratory is articulated, how it is then transformed, using the social as well as material artifacts in the environment, the form of its re-presentation and the data that the new form feeds into the process of investigation.

Keywords: *model-based reasoning, distributed & situated cognition, research laboratory, undergraduate*
Guide: Nagarjuna G.
Discussant: Arvind Jamakhandi

Notes

Revisiting transfer of learning in Mathematics: Insights from an urban low income settlement

Arindam Bose

Debates involving transfer of learning in mathematics are not new and there are arguments both in favour and against of it. Claims of situatedness of learning within tasks and non-transferability of knowledge between tasks are contested by challenging the very premise on which they are based. Different characterisations of transfer were in use mostly under a common paradigm of direct application of learning to a new problem which led to many instances of transfer failure. However, making use of an alternative framework, this paper argues that some of the transfer failures can actually be called partial transfer by broadening the paradigm of direct application of learning. It is argued that partial transfers can create scaffolds for effective learning and from a pedagogic viewpoint transfers and partial transfers can indicate possible ways to connect everyday mathematics with school mathematics. The paper further claims that the transfer problem cannot be addressed with a yes-no or either-or answer. Claims are supported by data drawn from an urban low income settlement where the sample middle graders are engaged in house-hold based small scale manufacturing units and possess diverse opportunities for gaining mathematical knowledge.

Keywords: *transfer of learning, situated perspective, affordance, everyday mathematics*
Guide: K. Subramaniam
Discussant: Sugra Chunawala

Notes

Non-formal & formal thinking in grassroot innovation

Geetanjali Date

Non-formal learning and problem-solving by grassroot innovators was one of the field study ideas I wanted to explore. I traveled to Jalgaon and Nagar districts of Maharashtra to meet some of the innovators nationally recognised by NIF. This presentation is an account of the insights gathered from the visit. Going further, such a study could seek to explore specific questions about the process by which people identify design problems and develop technological solutions to these problems, and whether the process can be understood in sufficient detail so that it can be taught as a part of engineering education.

Keywords: *grassroot innovation, NIF, problem-solving, non-formal education*
Guide: Sanjay Chandrasekharan

Notes

Notes

Annual Research Meet 2013

G 1 Lecture Room, Main Building

Date	Time	Speaker	Title	Discussant	Chairperson
23 September 2013	10:00 AM	Chitra Natarajan	**Welcome**		
					Chitra Natarajan
		Theme 1	**Higher Secondary & Tertiary Education**		
	10:15 AM	Prajakt Pande	**Learning with multiple representations in science, mathematics and engineering: A brief review of theoretical and empirical accounts**	Jayashree Ramadas	
	11:15 AM	**Tea Break**			
	11:30 AM	Shirish Pathare	**Understanding Thermal Equilibrium through activities**	Anwesh Mazumdar	
	12:30 PM	Anveshna Srivastava	**Measure concept-mapping, not concept-maps: Procedural Analysis elucidates stages in students' understanding of Biology concepts**	Jayashree Ramadas	
	01:30 PM	**Lunch**			
		Theme 2	**Primary & Secondary Education**		
	02:30 PM	Amit Sharma	**Understanding diagrams for inclusion**	G. Nagarjuna	
	03:30 PM	**Tea Break**			
	03:45 PM	Meena Kharatmal	**Trends in concept mapping research: A two decade review of literature**	Karen Haydock	
		Theme 3	**Non-formal Education**		
	04:45 PM	Rosemary Varkey	**Farmers' understandings of their own knowledge- Case studies**	S. Chandrasekharan	
	05:45 PM	Chitra Natarajan	**Closing remarks for the day**		
	08:00 PM	**Dinner**			

Annual Research Meet 2013

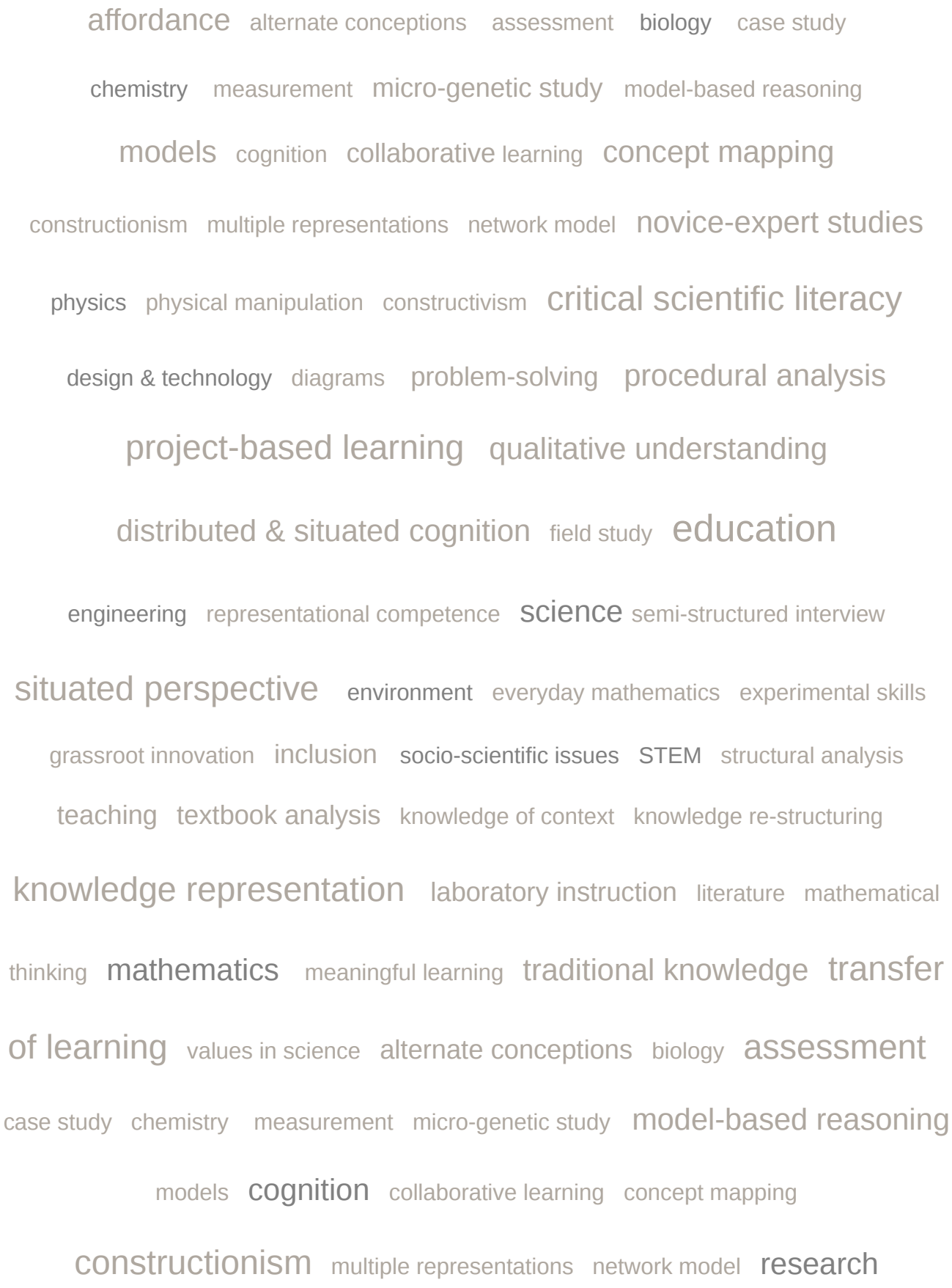
G 1 Lecture Room, Main Building

Date	Time	Speaker	Title	Discussant	Chairperson
24 September 2013	10:00 AM	K. Subramaniam	**Knowledge of Contexts for the Teaching of Mathematics**		Sugra Chunawala
	11:00 AM	**Tea Break**			
		Theme 4	**Teacher Education**		
	11:15 AM	Shikha Takker	**Making meaning of teachers' knowledge of students' mathematical thinking and its impact on classroom practice**	Jyotsna Vijapurkar	
	12:15 PM	Saurav Shome	**Exploring Indian teachers' views about and practice of school projects**	K. Subramaniam	
	01:15 PM	**Lunch**			
		Theme 2	**Primary & Secondary Education**		
	02:30 PM	Jeenath Rahaman	**Exploring the network model for area-measurement concept in classroom**	Jyotsna Vijapurkar	
	03:30 PM	**Tea Break**			
	03:45 PM	Rafikh Shaikh	**Learning to change the world: The social impact of one laptop per child**	Karen Haydock	
	04:45 PM	Gurinder Singh	**The state of experimental activities in Indian school science**	Karen Haydock	
	05:45 PM	Sugra Chunawala	**Closing remarks for the day**		
	08:00 PM	**Dinner**			

Annual Research Meet 2013

G 1 Lecture Room, Main Building

Date	Time	Speaker	Title	Discussant	Chairperson
25 September 2013	10:00 AM	S. Chandrasekharan	**Cognition, Science Education and Models**		K. Subramaniam
	11:00 AM	**Tea Break**			
		Theme 1	**Higher Secondary & Tertiary Education**		
	11:15 AM	Aswathy Raveendran	**Reproducing values: Examining how the higher secondary science curriculum discusses reproductive technologies from a critical scientific literacy perspective**	Karen Haydock	
	12:15 PM	Amit Dhakulkar	**Exploring the phenomena of Electromagnetic Induction**	Karen Haydock	
	01:15 PM	**Lunch**			
	02:30 PM	Shraddha Ghumre	**Exploring knowledge generating practices in a laboratory environment**	Arvind Jamakhandi	
	03:30 PM	**Tea Break**			
		Theme 3	**Non-formal Education**		
	03:45 PM	Arindam Bose	**Revisiting transfer of learning in Mathematics: Insights from an urban low income settlement**	Sugra Chunawala	
	04:45 PM	Geetanjali Date	**Short Presentation**		
	05:15 PM	K. Subramaniam	**Closing remarks for the day**		
	05:30 PM	Jayashree Ramadas	**Concluding remarks**		
	08:00 PM	**Dinner**			


affordance alternate conceptions assessment biology case study
chemistry measurement micro-genetic study model-based reasoning
models cognition collaborative learning concept mapping
constructionism multiple representations network model novice-expert studies
physics physical manipulation constructivism critical scientific literacy
design & technology diagrams problem-solving procedural analysis
project-based learning qualitative understanding
distributed & situated cognition field study education
engineering representational competence science semi-structured interview
situated perspective environment everyday mathematics experimental skills
grassroot innovation inclusion socio-scientific issues STEM structural analysis
teaching textbook analysis knowledge of context knowledge re-structuring
knowledge representation laboratory instruction literature mathematical
thinking mathematics meaningful learning traditional knowledge transfer
of learning values in science alternate conceptions biology assessment
case study chemistry measurement micro-genetic study model-based reasoning
models cognition collaborative learning concept mapping
constructionism multiple representations network model research