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Homi Bhabha Centre for Science Education

The 7th Annual Research Meeting
24th to 26th October 2016

Programme and Abstracts

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Introduction

The Annual Research Meeting of the HBCSE is our centre's forum for discussion of research results and ideas. The ARM has two main objectives - sharing your work and thoughts, and seeking feedback from the HBCSE community for improvements.

This year, along with research scholars and scientific staff from HBCSE, we welcome PhD students from the Indian Institute of Technology, Mumbai, as well as from the Department of Education of the University of Mumbai, to share their work with us.

The three-day long event includes 21 presentations on a wide variety of topics. We hope the event stimulates new ideas among its participants, leads to creative engagement with existing topics, and generates opportunities for fruitful collaboration.

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10:45 am	Interactive Vectors for Model-Based Reasoning **Durga Prasad K** Discussed by Dr. Aniket Sule
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12:45 pm	Building a Low-Cost Michelson Interferometer **Shirish Pathare** Discussed by Dr. Aniket Sule
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2:30 pm	The Role of Re-representing Linking Words in Concept Mapping for Developing Rigor and Expertise **Meena Kharatmal** Discussed by Dr. Sachin Datt
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4:30 pm	EVENING TEA

Day 2
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12:45 pm	A First Look at Second Year College Students' Understanding of Some Topics in Biology **Aakanksha Sawant** and **Swapnaja Patil**
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3:15 pm	Science Education and the Possibility of Social Transformation: Analyzing Educational Experiences of Adolescents from the M (East) Ward, Mumbai **Himanshu Srivastava** Discussed by Prof. Jyotsna Vijapurkar and Aswathy Raveendran
4:00 pm	Futures Orientation in the Discourse around Agriculture in Kerala School Science Textbooks **Rosemary Varkey** Discussed by Aswathy Raveendran
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5:00 pm	EVENING TEA

Day 3
Wednesday, 26 October 2016

10:00 am

Assessing the Test: Insights from Physics Olympiad Exam
Praveen Pathak
Discussed by Prof. K. Subramaniam

10:30 am

Interactivity is Necessary, but not Sufficient, for Imagination-Based Integration of Multiple External Representations

Prajakt Pande and Adithi Kothiyal
Discussed by Shweta Naik

11:30 am

TEA BREAK

12:00 pm

Probing 'Design Thinking' through Simulation Tasks: A Novel Tool to Elicit Thinking Strategies and Principles in Grassroots Engineering Design

Geetanjali Date
Discussed by Shweta Naik

12:45 pm

Development and Impact of Self-Directed Learning Package on Learning Readiness, Knowledge Management and Learner Empowerment of Student Teachers: A Mixed Method Study
Kalpana Chavan
Discussed by Dr. Sybil Thomas

1:30 pm

LUNCH

2:30 pm

Ableism and the Dialectical Nature of Mathematical Knowledge

Rossi D'Souza
Discussed by Dr. Sachin Datt

3:15 pm

Perception of Global Citizenship among Secondary School Students in relation to Critical Thinking, Social Justice and Service Learning
Priti Sivaramakrishnan
Discussed by Dr. Sybil Thomas

3:45 pm

TEA BREAK

4:15 pm

Student Questioning: A Way to Engage Students in Argumentative Discourse

Gurinder Singh
discussed by Shweta Naik

5:00 pm

Understanding Various Instructional Styles in Chemistry Laboratory

Sujatha Varadarajan
discussed by Gomathy Shridhar

5:45 pm

Closing Comments by **Prof. K. Subramaniam**

Abstracts

Mickey Mouse and the Big Evil Corporation: Visual Narratives of Environment

Charudatta Navare
Discussant: Prof. G. Nagarjuna

Visual narratives are a part of our culture in a plethora of ways. Visual narratives engage us in ways fundamentally different from textual ones. Hitler's most bizarre attempts at text refutation of anti-nazi cartoons provide a case in point. Taking this in view, I analysed visual narratives of the environment.

The dataset consisted of:
- images from Down to Earth, an environmental fortnightly
- environmental images from the Guardian, a British news and media website
- photographs of street art and graffiti around the world

Through discourse analysis, I identified key visual narratives being portrayed through these images. Here I present a brief overview of visual research methodologies, and then move on to discourse analysis in particular. I weigh in on the messages being conveyed through the environmental visual narratives. I conclude with implications the study has for environmental science outreach and education efforts.

Keywords
Science, Technology and Society

Charudatta is a second year research scholar at HBCSE. He loves to write in natural as well as in programming languages. A few of the things he's obsessed with include: comics, second world war, and evolution.

Interactive Vectors for Model-based Reasoning

Durga Prasad K
Discussant: Dr. Aniket Sule

Reasoning about the structure and behavior of physical phenomena using abstract and concrete models (model-based reasoning, MBR) is a key thinking skill in science and engineering practice.

One of the key areas MBR is introduced in the curriculum, particularly the use of abstract models, is applications of trigonometry, such as calculating heights and distances. In India, high school and pre-college (9-12 Grades) trigonometry curricula include three broad MBR cases: (i) heights and distances (ratios in right triangles), (ii) resolution and addition of vector quantities (projections in a unit circle to give the rectangular components), and (iii) periodic systems (represented as sinusoidal functions).

Students find trigonometry and its MBR applications difficult to understand, possibly because reasoning in this domain requires handling cognitive (internal/abstract) operations and symbolic (external/concrete) operations simultaneously, in different and complex ways, across these three MBR cases. A particular source of difficulty is the relationships between these trigonometric operations, which are not clear across the three cases.

We are developing an interactive new media system to help students learn model-based reasoning, based on MBR applications of trigonometry. Here we focus on vector resolution and addition, a key application supporting MBR. In the existing curricula, trigonometric and other concepts related to vectors are scattered across 4 textbooks, and students find it hard to integrate these scattered concepts. We report a study outlining how the new media tool helped students integrate the concepts involved in vectors, and the insights from the study for redesign, particularly to support MBR.

Keywords
Cognitive Studies of Science Learning, Design and Technology in School Education

Durga Prasad is a research scholar in the 3rd year of his PhD at HBCSE.

Problem Categorisation in Learning by Doing

Sachin Datt
Discussant: Prof. G. Nagarjuna

Learning by doing is a class of pedagogy that is built upon the idea that concepts can be understood in the act of creating a physical or conceptual artifact. It is also termed as experiential learning and forms the foundation of Design and Technology (D&T) education.

One of the key challenges in D&T education is to encourage creation of new ideas for fulfilling a variety of human needs like making houses, chairs, greenhouses, tractors etc. There are many theories in creativity research literature that include studies of how creative people across domains like art and science come up with new ideas. Some research has indicated that new ideas emerge spontaneously in the process of attempting to solve open ended problems.

The problem of finding new ideas then shifts to the problem of finding new problems. Whether a student discovers a new problem by herself or the facilitator chooses to give some open ended problems to students, in either case, the issue is selection of problems from a world of infinite problem possibilities.

Humans form categories for the purpose of organizing information. The selection of problems from an infinite pool of problems will be easier if problems were sorted into fewer categories. If we look at this issue from 'Exemplar and Prototype' theory of categorization, then our task is to find out prototypical nature of problems that have similar features and populate that category with many exemplars. Some possibility of categorization of design and technology problems are demonstrated by analyzing innovations registered with National Innovation Foundation.

We also look at the method of dichotomous pairing to classify design and technology problems into basic general categories from which other problems are derived.

Keywords
Design and Technology in School Education

Sachin worked as an animator in the area of E-learning after his BFA in Applied Art. He completed a Masters in Industrial Design focusing on educational communication. His PhD was in the area of using history of science narratives for organizing upper primary science curriculum. He developed content for History of Science and experimental science curriculum in Pratham Education Foundation prior to joining HBCSE.

Building a Low-Cost Michelson Interferometer

Shirish Pathare
Discussant: Dr. Aniket Sule

Michelson–Morley interferometer is an important and challenging experiment in many undergraduate as well as post-graduate physics laboratories. It is particularly satisfying experiment, both to teacher and to student, in that the student can obtain results which are commensurate with his/her skill and patience.

However, the apparatus required for this experiment is costly (₹30,000 to ₹2,00,000). Moreover in case of damage, the parts of the apparatus needs to be bought from the supplier only due to the design intricacies involved.

In this experiment, the wavelength of the source is measured by changing the path difference. Moving one of the mirrors can change the path difference. This movement is conventionally achieved by using a micrometer screw gauge assembly.

In this talk I present a low cost version of the interferometer, which is easy to set up. This interferometer has a special arrangement for the mirror displacement. With this new arrangement of mirror displacement, the mirror can be moved with an accuracy of less than a micron.

Keywords
Experiment Development

Shirish has been working in the Physics Olympiad cell of the centre since 1999. He is involved in training Physics Olympiad students in experimental physics.
He is also pursuing research work on students' alternative conceptions in Heat and Thermodynamics.
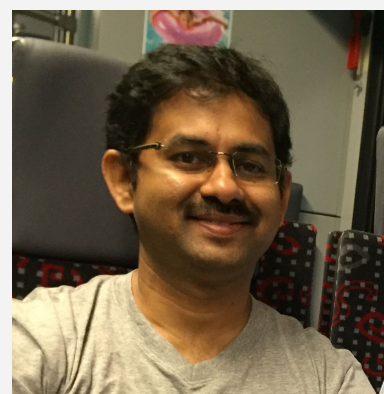
The Role of Re-representing Linking Words in Concept Mapping for Developing Rigor and Expertise

Meena Kharatmal
Discussant: Dr. Sachin Datt

Concept mapping has been used widely in different knowledge domains as a learning and assessment tool. Inspired by the semantic network principles, we introduce additional conventions to the standard concept mapping method in the domain of biology. This leads to the use of a controlled vocabulary of linking words ('Reference Set') to replace the linking words used in standard concept mapping. The Set of linking words is obtained from the Relational Ontology of the domain developed by the Knowledge Representation (KR) researchers. The suggested modification is rooted in the contemporary cognitive perspective of Representational Re-description (RR) and the ontology-based KR work. The propositions in the form of concept-link-concept were re-described by replacing the linking words by those in the Reference Set leading to the Re-represented Concept Maps (RCMs). The RCM makes the meaning of propositions more explicit and weeds out ambiguity. To examine the rationale for our re-representation, text-book passages were paraphrased in the area of cell biology for different grades from school to college level. The linking words in the textbook propositions were found to be increasingly proximate to those in the RCMs as the level increases from school to college. The near saturation of the number of linking words even as the number of concepts grow indicates a close connection with expertise. This suggests that the choice of linking words can be considered as an important marker of rigor and expertise.

Keywords
Structure and Dynamics of Knowledge

Meena's area of research work falls into Knowledge Representation, particularly focusing in Science Education. Her approach investigates the representation of scientific knowledge by focusing on the predicates rather than on the concepts.

Relationship between Secondary School Students' Educational Aspirations, Educational Resilience, Social Connectedness and Well-being: A Mixed Methods Research

Gomathi Shah

Monday, 24 Oct
3:30 pm

Adolescence is the transitional phase when a child goes through physical, psychological and emotional changes. It is the period of acquiring new capacities and responsibilities, which may have lifelong consequences, particularly on education, career and health. Especially in today's competitive era, every single child wants to reach the peak of success and that is the demand of the society. The adolescents are in the final stages of formal schooling and they start setting educational goals for their future. This goal setting process goes through a lot of ups and downs, influenced by various factors either promoting or hindering their well-being. The present study has thus made a deliberation to explore all those avenues of adolescence with respect to their educational aspirations, educational resilience, social connectedness and well-being to facilitate this passage of time easy for parents, teachers, and needless to say, the teenagers themselves. It used a mixed methods research design of the sequential explanatory type, conducted in two phases. The study sought to ascertain the relationships between the variables, develop a causal model of relationships and estimate the magnitude of causal links involved using path analysis. Further, the researcher attempted to answer few questions raised at the beginning of the study about the students' perceptions of their experiences and attitudes at that time of schooling by interviewing few students who scored at the extremes in the first phase. Strikingly, results showed connectedness to be the dominant variable on which educational aspiration, educational resilience and well-being are dependent on. Results integrated from both the phases conformed to the findings of previous studies with a few disclosures specific to the sample under consideration in the present study.

Keywords
Education Research

Gomathi is a Research Scholar at the Department of Education, University of Mumbai.
The present paper is a part of her doctoral dissertation, which is at the final stage before submission. She is enthusiastic about presenting the paper to invite critical feedback from scholars and enrich the quality of her research work before submission.

Mathematics Teachers' Understanding of Teaching Algebraic Identities

Shweta Naik
Discussant: Prof. K. Subramaniam

Algebraic identities play an important part in mathematics curriculum and in mathematics in general. Widespread research has been done to elicit and cognize students' errors of equality and of concepts around equality. Researchers report varied conception of "=" sign and how that functions in students' understanding of other algebraic entities. However, much less has been examined about the pedagogy for algebraic identities. This study, is part of a larger study on investigating teachers' knowledge to teach mathematics effectively, presents six cases of teaching algebraic identities. These cases have been analyzed for its mathematical explanations, use of representations, coherence with mathematical goals and described applications. There are two main findings: the role that identities play in mathematics and in the school curriculum has a major divide, and is created due to the preached pedagogy, and the explanations and representations used to introduce the concept are situated in algebraic identities through a pseudo–mathematical logic. Furthermore, the study derives knowledge of mathematics at the horizon for teaching equality in algebraic expressions.

Structure of the paper
A narrative of the emergence of algebraic identities in mathematics and in the school curriculum is given, followed by a brief discussion on students' errors in algebra, specifically of and about the equality in algebraic expressions. The description of the study, data analysis and results are then presented to propose knowledge of the mathematical horizon that shapes pedagogical goals and resources for teaching algebraic identities.

Keywords
Mathematics Education Research

Shweta has been working in the field of mathematics education research for over a decade. She joined the PhD program at University of Michigan with Prof. Deborah Ball in 2011. She is interested in learning what knowledge is needed to teach mathematics, and what aspects of doing mathematics have affordance to its pedagogy. Further, in her thesis she studies these aspects of doing mathematics in relation to equity in the classroom.

Understanding and Facilitating Knowledge Generating Practices in a Laboratory Environment

Shraddha Ghumre
Discussant: Dr. Shubhangi Bhide

I will describe an episode of knowledge creation by students in a peer-driven and discovery-focused undergraduate biology laboratory. The design principles underlying this experimental laboratory model are: bridging the gap between research and practice by bringing in authentic scientific practices in laboratory, linking teaching and research, setting up scalable research hubs at low costs across the country by means of Simple model systems based research, facilitating functional networking among different research hubs for building a community of learners to share knowledge and resources and addressing questions that connect different sub-disciplinary areas in biology. I will examine how the episode I have studied helps illustrate, support, and extend these design principles, in contrast with the design and practice of traditional undergraduate laboratories.

Some attempt will also be made to understand how the account relates to and raises some issues in philosophy of science particularly in the area of model based reasoning and explanations.

Keywords
Structure and Dynamics of Knowledge

Shraddha is a PhD student at HBCSE, working in the CUBE lab.

Doing Technology as if Ecology Mattered: Moving beyond Engineering Efficiency towards Education Aimed at "Solving for Pattern"

Geetanjali Date and Deborah Dutta
Discussant: Prof. K. Subramaniam

Human activities have adversely changed the landscape of the planet, prompting geologists to name the present epoch as 'Anthropocene'. In this paper, we argue that a parochial notion of efficiency embedded in conventional engineering design disregards the complex interdependencies that constitute the ecological system, and has had a major role to play in the current trajectory of unsustainable practices.

Envisioning sustainable practices require holistic perspectives stemming from engagements embodying 'Solving for Pattern' values . To this end, we propose two possible interventions that can play a role in making such values central to education, the first being urban farming at high school level, the other grassroots design at the undergraduate engineering level.

Keywords
Science, Technology, and Society

Geetanjali's thesis work is about socially-engaged engineering education with a focus on design of equitable, sustainable, and appropriate technologies for development. Her research focus is characterizing the design processes and thinking of 'grassroots designers'.

Deborah's thesis work is about community engagements that can promote environmental values. Her research focus is exploring urban farming initiatives as sites of developing motivation for pro-environmental action.

A First Look at Second Year College Students' Understanding of Some Topics in Biology

Aakanksha Sawant and Swapnaja Patil

We have recently initiated a project on the teaching of biology in introductory college courses. Our aim is to investigate how some of the elements of effective teaching that we have identified at the school level can be incorporated in college courses. As a part of this project, we conducted a baseline test followed by interviews with second year biotechnology and microbiology students of a reputable college in Mumbai. The topics covered in the test were sterilization, cell membrane, and evolution. This exercise was done to gain insights into their conceptual understanding of these topics at a level that is expected of them by the end of their first year B.Sc. We present results of some of the preliminary analysis of this data.

Keywords
Education Research

Swapnaja has a Master's degree in Medical Biotechnology and **Aakanksha** in Biotechnology. But that was before they joined this Centre; now they thoroughly enjoy working in education research under the guidance of Prof. Jyotsna Vijapurkar.

Effectiveness of a Cyber Bullying Sensitization Program (CBSP) for Enhancing Sensitivity towards Cyber Bullying among Secondary School Students

Surabhi Negi
Discussant: Dr. Sunita Magre

The aim of this study is to test the effectiveness of the Cyber Bullying Sensitization Program (CBSP) in raising awareness against cyber bullying among secondary school students, thereby reducing cyber bullying behaviors. The program specifically targets adolescents who are at risk of exposure to cyber bullying. For this study, an experimental design with a control group will be utilized. The Cyber Bullying Sensibility Scale will be administered to the experimental and the control groups before and after the program. The implications for prevention and intervention programs will be discussed.

Keywords
Education Research

Surabhi is a freelancer in the field of guidance and counselling. She is a trained life skills coach and has worked actively with CBSE in collaboration with Expressions India. A member of All India Association of School Counsellors and Allied Professionals (AISCAP), She has worked as a Counsellor for five years with Cambridge School Indirapuram. She is a researcher at heart and is currently pursuing her Ph.D. in Education under the UGC Junior Research Fellowship Scheme at the Department of Education, University of Mumbai.

Science Education and the Possibility of Social Transformation: Analyzing Educational Experiences of the Adolescents from the M (East) Ward, Mumbai

Himanshu Srivastava

Discussants: Prof. Jyotsna Vijapurkar and Aswathy Raveendran

Tuesday, 25 Oct

3:15 pm

One of the largest dumping sites in the country, the Deonar dumping ground, is situated in the M (East) ward in Mumbai. The area close to the dumping ground is densely populated by thousands of migrant families (mostly Muslims and Dalits). Extreme poverty, poor hygienic conditions, lack of access to public health services, unavailability of drinking water, and polluted air characterize the area. The Human Development Index for the M (East) ward is a mere 0.05. This is the context in which I am trying to explore the possibility of transformation through science education.

In this paper, I start with reflecting on what could transformative science education mean for this community. It is followed by a report of the preliminary findings of a part of my main study in which I explore the nature of educational experience the adolescents from the community go through as part of their formal science education.

Classroom observations were conducted in five schools in the area when topics related to waste management, health and regional development were taught. The relevant textbook chapters were also analyzed from the Bernsteinian perspective of 'classification' and 'framing' of educational knowledge. The analysis shows that these topics are presented in an insulated manner. The classes run in a didactic fashion with very little room for students to raise concerns, share experiences, or ask questions. The pedagogical practices across schools disregard the lived reality of the community. The control over content lies mostly with the teachers, though the structure and the examples discussed in a class are largely determined by the textbook. The textbook works as a gatekeeper and maintains a 'strong' boundary between the knowledge worth teaching and the experiential knowledge of the community.

Based on the preliminary analysis of the data, it's argued that by not including concerns and questions of the students, and by deliberately silencing their voices in the textbooks and classrooms, the current educational experience is essentially disempowering these students.

Keywords

Science, Technology, and Society

Himanshu is a PhD student working in the area of STSE education.

Futures Orientation in the Discourse around Agriculture in Kerala School Science Textbooks

Rosemary Varkey   Tuesday, 25 Oct
Discussant: Aswathy Raveendran   4:00 pm

Conflicts and consensus amongst the structure, process, content and value orientations of curricularists are an integral part of curriculum planning and design. Critical curriculum theorists were instrumental in sensitizing about hegemonic assumptions and values that influence the curricular imaginations through their exposition of stated and hidden curricula in action. Content oriented curriculum theorists criticize the critical theorists of shifting the focus from 'pupil's entitlement to powerful and shared knowledge', which they see as the basic purpose of education. These debates are very much part of science education too.

Knowledge from the domain of science studies have contributed and continue to do so in the debates between various curricular imaginations of science education. Science studies inform science, technology and society (STS) studies, nature of science studies (NoS), history and philosophy of science (HPS), the study of socio-scientific issues (SSIs), more recently, future studies. Research in science education has also evolved while dealing with the need to broaden science education to accommodate STS, HPS, NoS, SSI, and future studies over time.

Futures oriented theorists see the above debate as the new normal (in a Kuhnian sense) in science education and most of the current research in science education as the puzzle-solving activities within this 'normal'. They argue that the 'post-normal' science education research should orient itself to identify and address the 'blind-spots' for a science education suitable to the 'post-carbon anthropocene'. They draw current understandings from science studies that acknowledge the interconnectedness, interdependency, and unpredictability of environment-science-human society complex that conceive the nature as 'inextricably entangled with us' instead of 'apart from' or as 'an object of inquiry.'

In a textbook centric education system like that of India, textbooks are the foremost sites of negotiations between various curricular imaginations. This paper is an attempt to understand the discourse around agriculture in the school textbooks taught in Kerala during the years 1896-2015 in the backdrop of the above understanding of various curriculum theories. This discourse has evolved from transacting traditional understandings in farming to celebrating science and most recently, to acknowledge the changing perspectives in science and the need for sustainable agriculture. A shift in the formulation of learning outcomes from accumulating knowledge about agriculture to appreciating the importance of 'our choices today create our future' could be seen. Though recent discussions on agriculture in science textbooks acknowledge the complex relationships between science, society and nature, they are not completely devoid of some of the 'blind-spots' as explained by futures theorists, like treating science, society and education as 'entities out there' that already exist.

In this analysis, historical events that transformed the collective consciousness of the Kerala society from time to time emerge as an important element in the creation of an education system sensitive to futures orientation. An internalization of 'the different

possibilities of future and that we are actively creating the science, society and education constantly, with the choices we make now' framework of the futures orientation renders the possibility of replicating the desirable outcomes elsewhere, even without the presence of such a collective consciousness.

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Keywords
Futures Orientation in Science Education

Rosemary is researching on the relationships between agriculture, science, education, and society.

Assessing the Test: Insights from the Physics Olympiad Exam

Praveen Pathak
Discussant: Prof. K. Subramaniam

Wednesday, 26 Oct
10:00 am

One of the key aspects in the selection process for any examination is the quality of the question paper. Exams like Indian National Physics Olympiad tests students understanding at higher level and aims at selecting top 10% students for next level of selection process. This higher secondary level exam has 5-6 subjective guided questions to be solved in a time span of three hours. A subjective question is difficult to grade and students are also eligible for partial marks. Many times there are more than one ways to solve a problem. In such a scenario what should be the ideal criteria to decide how successful a subjective question paper is? Efficiency of an item can be judged with several parameters. Parameters such as average marks and standard deviation give average insights about the performance of a question. This study aims to look at INPhO 2016 question's performance in light of parameters used in education measurement theory such as difficulty index and discrimination index.

Keywords
Educational Measurement

Praveen has been a member of the physics olympiad cell since he joined HBCSE in 2006. His area of research is theoretical nanoscience and physics education.

Interactivity is Necessary, but not Sufficient, for Imagination-Based Integration of Multiple External Representations

Prajakt Pande and Aditi Kothiyal
Discussant: Shweta Naik

Science, mathematics and engineering deal with entities and phenomena that often cannot be directly perceived or interacted with. Multiple external representations (MERs) are thus critical to understanding, problem solving, modeling and design in these domains. Representational competence (RC) is the ability to simultaneously process and integrate MERs in a domain, and imagine the entities and phenomena through respective MERs. Student difficulties in learning as well as conceptual understanding have been attributed to problems in working with MERs. Studies comparing experts and novices in various domains show that experts are much better in their usage and generation of MERs.

Computer interfaces have been used extensively in science, mathematics and engineering learning for the learning goals of improving conceptual, phenomenon and procedural understanding using MERs. These interfaces typically seek to achieve these goals by presenting MERs (often simultaneously) for explicating structures, qualitative and quantitative relations between variables and phenomenon dynamics. A few interfaces also allow students to control these and other aspects. Studies show that the effectiveness of these interfaces is mixed. One possible reason for this is that the principal goal of most such interfaces has been to improve conceptual understanding, and not RC. Moreover, current interface designs are guided by information processing theories of cognition, wherein the role of the interface is to decrease the learner's cognitive load, particularly working memory load. It is unclear how MER processing and integration contributes to cognitive load, and hence how interactive systems reduce the load. Given the ubiquitousness of MERs, it is important to develop an account of the cognitive mechanisms involved in MER integration, and then develop focused interventions that support this integration.

In this paper, we report the design, development and testing of a fully manipulable computer interface, which was designed as an intervention tool to support MER integration, as well as a probe to help provide an understanding of the process involved in MER integration. The system has manipulable and fully interconnected MERs (physical behavior, graph and equation) representing a simple oscillator (pendulum) system. We assessed MER integration using this interface, with nineteen 7th grade students, who interacted with the interface for an hour. They then answered, and verbally reasoned about, questions that tested MER integration as well as imagination of the oscillation phenomenon. Students' actions on the interface, particularly eye-movements and mouse clicks, were recorded during the interaction with the interface. These were correlated to their responses, to understand actions (patterns of interaction) that could have potentially led to integration.

The results provide a very nuanced view of the relationship between interaction and integration. Good performers (on the MER integration tasks) had a high level of interaction, but with significant variations between participants. This suggests interaction is needed for integration, but there is no single interaction pattern supporting integration. However, high level of interaction did not guarantee

integration/imagination, as students exhibiting similar interaction patterns as the good performers performed badly in the integration tasks. This suggests interactivity is not sufficient for MER integration. The results indicate that interactivity can scaffold MER integration, but cannot guarantee it. Support from facilitators is needed for MER integration, as in any other complex task where novices' attention needs to be guided.

Prajakt obtained Masters in Biotechnology and Biochemistry before joining HBCSE, but doesn't remember much from those disciplines now! He deeply enjoys singing, playing table tennis, watching and critiquing movies, cooking, travelling and solitude!
Apart from that, he is currently interested to understand the nature of and cognitive mechanisms involved in imagination of scientific phenomena. He is also interested to know how this understanding may be translated into learning environments.

Aditi is a research scholar in Educational Technology at IIT Bombay. In a previous life, she obtained an MS in Electrical Engineering from The Ohio State University. She knows just enough of her parent discipline to recognize that she is not a good engineer. So now she works in engineering education to make better engineers, particularly in the design of technology-enhanced learning environments for engineering thinking skills such as problem solving, design and estimation. When she is not doing that, you might find her observing her seven-year-old, who is the reason for her interest in understanding human cognition. You might also find her cooking, blogging and discovering the lost corners of the IITB campus.

Probing 'Design Thinking' through Simulation Tasks: A Novel Tool to Elicit Thinking Strategies and Principles in Grassroots Engineering Design

Geetanjali Date
Discussant: Shweta Naik

In my study of grassroots design, the data of a formally trained engineer (EP) and the non-trained grassroots innovator (GRI), are collected through semi-structured interviews, artefact details, photos, and secondary data from reports of their installations. While these data give a sense of their design processes, we do not get sufficient insight into their mental models of electricity and its generation (process), as well as each component in the design of a micro hydro power station.

It is also seen that though the geographic opportunity for micro hydro power is similar in both the cases, the socio-cultural, economic, and political contexts are very diverse / dissimilar. EP and GRI themselves bring distinct backgrounds and relationship with the context to the problem. As we try to understand the ways in which EP's and GRI's mental models are similar or different, in the interview mode they have to resort to memory, and it is difficult to ask specific questions about each component.

An actualised system, where they generate the process using the components, would help us probe and elicit rich qualitative data. We could also be able use the same tool to probe the design thinking of formally trained students who do not practically engage with the design of a real-world micro hydro power station.

Towards this, Harshit Agrawal and I developed a (virtual) simulation tool that can engage both these individuals in specific (and same) problem situations, and allow me to elicit details of design decisions. In this presentation, we share with you the design of this research and the tool, as well as some learnings from the trials we conducted with it.

Keywords
Engineering Design Education

Geetanjali, a research scholar at HBCSE, belongs to the Learning Sciences Research Group led by Dr. Sanjay Chandrasekharan, who is also her thesis advisor. Her research area is at the confluence of engineering design education, engineering studies, and cognition and learning sciences, at undergraduate level. Her research project is to understand / characterize the design processes and thinking of 'grassroots designers' — formal and mostly non-formal practitioners who design engineering solutions to address the needs of the 'base of the pyramid' sections of the society.
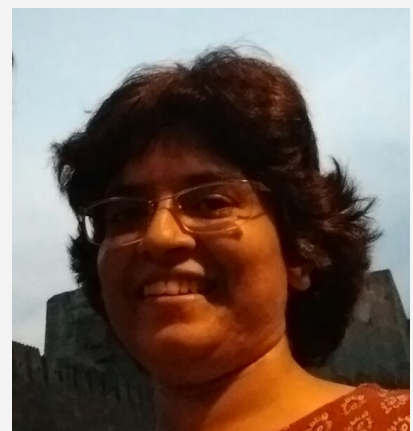
Development and Impact of Self-directed Learning Package on Learning Readiness, Knowledge Management and Learner Empowerment of Student Teachers: A Mixed Method Study

Kalpana Chavan
Discussant: Dr. Sybil Thomas

Each individual has a fundamental urge to grow: to achieve greater maturity and self-direction (Knowles, 1950). Through self-directed learning, learners can be aware of their learning needs, formulate learning strategies, take ownership, learn to manage knowledge and achieve learning goals for oneself. Knowledge Management develops systems and processes to acquire, increase and share individual and team learning. Learner becomes empowered when he is increasingly taking charge of his learning, is motivated to perform tasks, feel more competent, find tasks meaningful and feel they have impact on their learning processes (Housser, Frymur, 2009).

The aim of this research is to develop a Self-directed Learning Package (SDL) which can empower learners, (here student teachers), by cultivating the skills of self-directed learning and knowledge management skills. The research will study the impact of SDL Package on Learning Readiness, Knowledge Management and Learner Empowerment of student teachers. The study will focus on the interactive influence of low, moderate and high learning readiness learners and impact of SDL package. The study intends to study the relationship between the overall scores of the three variables. Null hypothesis will be proposed for the above objectives.

A comparative quasi experimental design will be used for the study. The research method will follow embedded mixed method. The research will be conducted in 3 phases. Data Analysis would include for quantitative mean, median, mode, t-test , ANOVA and coefficient of correlation. For qualitative open, axial, coding and interpretation.

The present study will be useful to learners, teachers, curriculum designers, policy makers and prospective employers.

Keywords
Self-directed Learning Package, Learning Readiness, Learner Empowerment, Knowledge Management

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Kalpana is a doctoral student under the guidance of Dr. Sybil Thomas at the University of Mumbai, Education Department. She has Completed Masters in Philosophy, Sociology and Education with NET cleared in all three Masters. She is an Assistant Professor at St. Xavier's Institute of Education, since 2004. She has taught the following subjects: Foundations of Education, Inclusive Education and History method. Her areas of interest are: Reflective Thinking, Dialogue Based Education, Theories of Learning and Approaches to Learning.

Ableism and the Dialectical Nature of Mathematical Knowledge

Rossi D'Souza
Discussant: Dr. Sachin Datt

I propose a framework for analysing students learning of mathematics. Terming it "the dialectical nature of mathematical knowledge", I present it as a radical departure from, and problematize the "misconception" view of knowledge. I argue that contradictions are inherent in every conceptual framework and that knowledge develops through resolution of contradictions. I also present limitations within contemporary discourses on disability and present a dialectical view of Ableism. I argue that Ableism is a structure that includes everyone – not just people with disabilities. While Ableism oppresses some people, it also privileges a few.

Keywords
Nature of Mathematics Learning

Rossi is a research scholar working on the topic of Ableism and Mathematics education.

Perception of Global Citizenship among Secondary School Students in relation to Critical Thinking, Social Justice and Service Learning

Priti Sivaramakrishnan
Discussant: Dr. Sybil Thomas

Human beings on earth are not just citizens of the state, region or country they belong to, but are a part of the big world. The world is one family and we have to live together in peace and harmony like a family. Global citizenship means one is a citizen of the world who adopts and understands communities across the world and is a part of the larger world community. In order to have learners who can actively and confidently contribute to the global society we need to have students who are self – directed learners who can think critically, gain experience and exposure in the community. Critical thinking alone will not suffice, the ability of students to explore issues thoughtfully - offers a way to speak out against injustice and unfairness is equally important. Critical thinking through service learning would enrich and enhance students' learning to be globally competent citizen. The aim of the study is study the secondary school students' perception of global citizenship in relation with critical thinking, social justice and service learning.

The objectives of the study is to ascertain the relationship of Global Citizenship and critical thinking, global citizenship and social justice and global citizenship and service learning. Data would be collected from 500 secondary school students of standard 9th or 8th. The data would be subject to descriptive and inferential analysis.

This study makes a serious attempt to analyze how secondary school students familiarize themselves and absorb the concept of global citizenship and reflect on their own thinking. The study would benefit all the stakeholders in the field of education. The study would also contribute to bring out the need to frame the curriculum in a manner in which conscious attempts are made to include the concept of global citizenship. The study will help the teachers to inculcate global values to the future citizens of the world.

Keywords
Education Research

Priti is an Assistant Professor at the St. Xavier's Institute of Education, Mumbai. She holds M.Com. and M.Ed degrees, and is registered as a PhD student at the University of Mumbai.

Student Questioning: A Way to Engage Students in Argumentative Discourse

Gurinder Singh
Discussant: Shweta Naik

Science educators have not yet paid adequate attention to the role of student questioning in their argumentation. To address this gap, we explored the role of student questioning in engaging students in argumentative discourse. This was done by analysing middle school students' talk as they asked and investigated their own authentic questions. The study was planned and conducted using naturalistic inquiry methods. The data was collected using audio-video recorders, students' written work and researcher's' notes. The tapes were transcribed and analysed using conversation analysis methodology. By analysing a few of the student questioning episodes we describe here some instances of student engagement in authentic argumentation. In these episodes we found that a question posed by one student initiated cycles of questions and arguments among students. Through this study we propose that for engaging students in authentic argumentation, we must let students pose their own authentic questions, which they ask for genuine reasons. This is more apt to occur when students interact with real objects.

Keywords
Science Inquiry

Gurinder has been conducting research on student questioning to understand the role of the teacher, the context and the student-student talk in the student questioning process. His areas of interest include student questioning, student talk in student initiated discourses and student argumentation.

Understanding Various Instructional Styles in Chemistry Laboratory

Sujatha Varadarajan
Discussant: Gomathy Shridhar

The paper presents a brief overview of the historical development of chemistry lab instruction and also discusses in detail current instructional styles that constitute a part of college level chemistry lab course.

The need, role and nature for laboratory education in teaching of chemistry are some of the Chemistry Education Research (CER) areas. This is because, chemistry is an experimental science and practical work is an essential component of chemistry right from the days of alchemy and iatrochemistry. In order to appreciate the experiential learning that can be effected in the lab, it is important to understand the objective and nature of lab instruction. The paper analyses different instructional styles with respect to its nature, objective, advantages and disadvantages as well.

Keywords
Education Research

Sujatha is interested in pursuing research in chemistry lab education.