epiSTEME - 1

An international conference to review research on Science, TEchnology and Mathematics Education

International Centre, Dona Paula, Goa, India
December 13-17, 2004

Abstracts of Presentations

Organised by:

Homi Bhabha Centre for Science Education
Tata Institute of Fundamental Research, Mumbai, India

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This event is organised by the Homi Bhabha Centre for Science Education, a National Centre of the Tata Institute of Fundamental Research, Mumbai, India. It is the first in a proposed series of biennial conferences meant to review research world-wide in science, technology and mathematics education.

Topic of the conference:

Over the last thirty years, science, technology and mathematics education have emerged as lively new research areas. This research, inspired by issues of learning and teaching, has clear uniting themes in the cognitive, pedagogical, historical, philosophical and socio-cultural aspects of the sciences. The name epiSTEME connotes, at one level, a systematic study of knowledge, while as acronym it suggests a meta-view of science, technology and mathematics education.

Aim of the conference:

The conference will survey the global progress of research in science, technology and mathematics education by inviting leading scholars in the field to give overviews of notable areas of current work. Paper and poster sessions will complement the reviews and will aim to identify promising directions for future research. In the Indian context this series of conferences will strive to nurture a research community in the country while fostering interaction between academic research, teaching and curriculum development. The conference should strengthen academic linkages among research groups in this field across the world.

Themes:

- Trends in Science Education Research
- Trends in Technology Education Research
- Trends in Mathematics Education Research
- Cultural issues in Science, Technology and Mathematics Education
- Gender Issues in Science, Technology and Mathematics Education
- Knowledge Representation
- Language and Cognition
- Assessment and Measurement
- History and Philosophy of Science: Implications for STME

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Trends in Mathematics Education Research

Language and Cognition

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This review of the field is guided by a certain reading of the current situation, with which I therefore begin. Cognition by humans always appears in pedagogically cultivated forms. Normal questioning about such cognition thus always frames itself within the terms of some pedagogy. Asking questions about human cognition without reference to pedagogic frames is not an option available to us.

However, philosophers who take the primary responsibility for organizing our understanding of semantics and cognition have often tried to fashion such an option, acting on a logicalist impulse. This impulse seeks disengagement from the concrete sequentiality of pedagogy and its need to provide tentatively viable concepts and generalizations even though these ultimately have to be outgrown. The logicalist approach supposes that any subject, institutionally available as an academic discipline (a set of serious discourses), can be reduced to variously organized arrays of formally simple primes. It supposes also that these primes, through a rigorous axiomatic unpacking of their interrelations, can parsimoniously derive all the complex concepts and propositions that the discipline uses.

Scholars who believe in the usefulness of logicalism's restatement of a discipline's results see the activity of such redescribing as a matter of arranging the results in formal packages whose coherence and consistency represent what the best minds in the discipline can be said to know. The enterprise of formalizing such systems naturally elicits second order projects of metasystem building. The vision of a fully understood language of a unified science that will have brought all disciplines under maximally parsimonious reduction, and of a fully understood scientific language wherein coherence, consistency and economy can be visibly maximized, continues to serve as a telos guiding scientific formalization. In this sense the logicalist programme is alive and well, and is one of the major presences in the study of the language-cognition interface.

Given such a picture of the realities of what there is to know, a psychology that considers problems of learning takes as its point of departure the standard portrayal of the ultimate content of serious adult human cognition, and asks how a child gets there. This relation between a logicalist account of the goal and a psychological account of the path places the burden of pedagogy entirely on the psychology. But such assumptions conceal from the view the important fact that the standard portrayal of the serious adult goal is tacitly framed in a pedagogic conceptualization. It has been necessary, in the remarks above, to refer to academic disciplines, and to the best minds in the field. These are allusions, if not to teaching, at least to watching people learn and evaluating their performances, which belong to the broader pedagogic enterprise.

But there are at least two reasons for not pressing for a simple pedagogic turn in the study of language and cognition. First, domains of language use are organized in one fashion in the world of work, another way in the world of media and public communication, and yet another way in pedagogy proper. These are three distinguishable phenomenal realms. To approach the study of how they co-articulate, we need to first have these distinct takes on cognition, and we have not yet been able to catch them.

The second, related point is that the easy and the difficult in pedagogy fail to match the simple primes and complex assemblies of the formalization in the stories sciences tell about themselves. Therefore we will achieve only limited success if we try to carry over the style of scientific concept packaging into our understanding of how the easy and the difficult play out in pedagogy. Issues of more opaque versus more transparent expositions in public communication present yet another domain into which one cannot usefully export the formalization style if advances in our understanding are the goal.

The differences just pointed out have long been obvious in practice to natural scientists, who tend to respond to this state of affairs by treating both the teaching of science and the technological application of scientific knowledge as atheoretical enterprises not integrable into its rigour. In contrast, science itself appears in their work as a body of bodies of theory. This appearance continues to shape our default conceptions of both language and cognition.

However, current work on the role of language and translation in the practice and teaching of science (Sarukkai, 2002) speaks to classical work (Vygotsky, 1934/1986) on the way image-based preconcepts must, as the adolescent schoolchild grows into serious knowledge, turn into the abstractions operative in society's adult, industrial economy. Taking these matters on board means supplementing the logical derivation approach with pedagogic build-up perspectives on how various real learners converge on sharable knowledge. The task of such supplementing is cognate to inquiry focused on how a person acquiring language also learns what one might call paracognitive material that does not itself constitute knowledge but categorizes or frames the knowledge that the person acquires (Sperber, 1975). The present survey of where the field stands is built around Sarukkai's demonstration that formal abstract concepts are embedded in multiple semiotic systems and need to be placed in translation mediations that never settle down. On these assumptions, the formalism that officially explicates what scientific language codes are like is relativized to intercodal activities that Sarukkai places in a pedagogic framework. The methods of translation studies enable us to coarticulate our distinguishable questions about simple/ complex, easy/ difficult, transparent/ opaque. Given a translation studies approach, the domains of adult scientific practice, of science pedagogy, and of the media can be kept apart and yet brought into meaningful conceptual connection.

Sarukkai's emphasis on metaphor connects with Sperber's earlier work on the cognitive anthropology of the symbolism circumscribing what humans know, and ultimately with Vygotsky's work on how serious knowledge relates, and relates in the structure of language itself, to the not yet properly understood affective and imaginative coordinates that make human knowledge human.

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What Impact does Philosophy of Science have on Current Science Education Research?

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It is important to ascertain the impact of various philosophies of science on science education research. One expects views about the nature and methodology of science to have an impact on the questions and problems to be investigated by science education researchers, on the methodologies employed in research, on recommendations for the 'reform' of science education curriculum and teaching, and on a host of other matters.

However getting a precise picture of the impact of philosophy on science education research is difficult. The amount of research and publications in the field over just the past three decades is enormous. There are at least six major international science education research journals publishing perhaps 300 articles per year, additionally there are numerous national and teacher-focused journals. The Helga Pfundt and Reinders Duit's 4th edition of the *Students' Alternative Frameworks and Science Education* bibliography contains 4,000 entries. However a recent book of Peter Fensham *Defining an Identity* (Fensham, 2004) – provides a rich source of material for at least a partial, if depressing, answer to the question.

Peter Fensham, was the foundation professor of science education at Monash University in Australia; he is a prominent figure in international science education, whose work has been the subject of a recent anthology (Cross, 2003). His *Defining an Identity* is based on interviews with 79 leading science educators from 16 countries (48 being from the USA, Canada, Australia and Britain) and their responses to questions about their own major publications and the publications that influenced them. They were asked to respond to two questions:

- Tell me about two of your publications in the field that you regard as significant.

- Tell me about up to three publications by others that have had a major influence on your research work in the field.

In fifteen chapters he then discusses the interviewees' major publications and the publications they nominate as influencing their work.

The interviews do reveal a significant problem with 'The evolution of science education as a field of research': namely researchers in the field are ill-prepared for conducting much of the research. Fensham remarks on many occasions that the pioneer researchers came into the field either from a research position in the sciences or from senior positions in school teaching. For both paths, training in psychology, sociology, history or philosophy was exceptional.

This failure of preparation did not change for second generation or younger researchers. Indeed it has perhaps got worse, as proportionally fewer science education researchers have the experience of scientific research that the founders of the discipline had. The interviews reveal that the overwhelming educational pattern for current researchers is: first an undergraduate science degree, followed by school teaching, then a doctoral degree in science education. As Fensham remarks 'Most researchers in science education have been teachers in schools, usually secondary ones, before their academic appointments' (p.164). Most have no rigorous undergraduate training in psychology, sociology, history or philosophy. At best, as Fensham observes, 'As part of their preparation for the development tasks, these teachers had opportunities to read and reflect on materials for science teaching in schools and education systems that were different from their own limited experience of science teaching' (p.22).

One effect of poor preparation is the extent to which shallow philosophy is so evident in the field. Fensham notes that 'About one fifth of the respondents listed a publication of influence from the history and philosophy of science' (p.56), and he goes on to comment that 'However, only two of these respondents were researchers who began after the 1980s' (p.56). The philosophers of influence among the first generation researchers were James Conant, Joseph Schwab and Thomas Kuhn. Second generation researchers also mention Thomas Kuhn, with one saying 'Thomas Kuhn's *Structure of Scientific Revolutions* is one of the few books I've reread several times … It was extremely helpful in my thinking with all sorts of implications for teacher education and everything I did' (p.56).

The second most influential philosopher for Fensham's 'Top 80' researchers is Ernst von Glasersfeld. Fensham states that 'von Glasersfeld's many writings on personal constructivism have had a very widespread influence on researchers in science education …. In their published research he is regularly cited as a general source for constructivist learning'; he is a person who has had a 'most significant influence' on science education research (p.5).

One interviewee, and enthusiast for von Glasersfeld's constructivism, has written that: 'according to radical constructivism, we live forever in our own, self-constructed worlds; the world cannot ever be described apart from our frames of experience. This understanding is consistent with the view that there are as many worlds as there are knowers' (Roth 1995, p.13). He goes on to state that 'Radical constructivism forces us to abandon the traditional distinction between knowledge and beliefs. This distinction only makes sense within an objective-realist view of the world …' (p.14). And for good measure he adds that: 'Through this research [sociology of science], we have come to realize that scientific rationality and special problem solving skills are parts of a myth' (p.31).

Another indicator of inadequate foundational training is the extent to which the claims of the 'Strong Programme in the Sociology of Scientific Knowledge' (SSK) are uncritically endorsed by interviewees. Fensham reports that: 'One book stood out as an influence about the culture of science and that was Latour and Woolgar's *Laboratory Life*' (p.58). One interviewee said the book 'legitimised the notion that you could study science from an anthropological perspective' (p.77). Another interviewee has stated that contemporary social studies of science reveal science to be: 'mechanistic, materialist, reductionist, empirical, rational, decontextualized, mathematically idealized, communal, ideological, masculine, elitist, competitive, exploitive, impersonal, and violent' (Aikenhead 1997, p. 220). Clearly a lot hinges on the correctness or otherwise of this analysis. If Aikenhead's picture is a correct account of the scientific enterprise, then teaching science is truly a problematic activity.

This paper uses the evidence in Fensham's book to elaborate the claim that a good many of the research programmes in science education have suffered because researchers are not adequately prepared in the foundation disciplines that underwrite these programmes – specifically learning theory (including cognitive science), philosophy (especially the history and philosophy of science) and history. Fensham acknowledges that researchers are ill-prepared, that they 'borrow' from the foundation disciplines, and that a major problem is that 'Theoretical positions were being presented and used in a form that suited the authors' studies, although this theoretical position had been revised as a result of studies and work these authors had not read or wished to ignore' (p.144). So the work of Kuhn, von Glasersfeld, Latour, Bruner, Lave, Harding, Giroux and others is appropriated but the critiques of their work go unread; it is rare that science education researchers keep up with psychological and philosophical literature. This situation means that the field is susceptible to intellectual and ideological fads that retard the primary business of assisting science teaching and learning, as well as the secondary business of the personal growth of the researchers.

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Layers in the Fabric of Mind: A Critical Review of Cognitive Ontogeny

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Cognitive science, particularly in the last three decades, witnessed several creative moments and innovative proposals on several issues related to cognition – the nature of mind, naturalized epistemology, cognitive development, biological roots of cognition, and an attempt to understand what is it to be distinctively human, scientific, theoretical, and socio-cultural. Encouraging leads to the underlying biological roots of cognition also came from neuro-physiological investigations as well as theoretical biology. Cognitive architectures based on information processing approaches are gaining strength and becoming popular and getting closer to being accepted as the received view on the subject. This multi-disciplinary discourse, along the way, not only reenacted several traditional philosophical positions, but also exhibited considerable innovation in rephrasing the traditional questions guided by a huge corpus of scientific findings from AI, physiology and pathology, and ingenious experiments on cognitive agents (both non-human and human subjects, including infants in the crib). While taking note of the achievements thus far, I wish to identify some conceptual and foundational problems in the dominant trends of current cognitive science. Given this vast multi-dimensional canvas, a single essay cannot do justice to critically review the area. I will therefore focus here on what I consider as fundamental issues that must have a bearing on cognitive science and science education as a whole. Approaching these problems as an epistemologist I will focus on the issues closer to naturalized epistemology and architecture of mind than on empirical cognitive psychology.

It is celebration time for rationalists and constructivists. Gone are the days when mentalese was more or less forbidden in academic departments. Cognitive phenomena does not constitute merely the behavioral (stimulus-response) patterns of a 'black-box'. Constitutive reality (both form and substance) of the cognitive agent is today considered highly relevant for the scientific study of mind. There are predominantly two kinds of camps: those who believe that cognitive faculties are completely specified by the innate biological reality (Noam Chomsky, Jerry Fodor), and those who believe that they develop during ontogeny based on incompletely specified 'embryological' reality (Karmiloff-Smith, Susan Carey, Alison Gopnik). While it is possible to identify other positions that are in neither of the camps, a significant point to note is, almost none of the modern views are of the traditional rationalist or empiricist variety. Most of the current pundits reformulate the older questions so as to make them addressable by scientific means: towards a naturalized (more or less genetic) epistemology. According to the current trend, Piaget's theory of across the domain mechanism of cognitive development found no experimental support. Instead they painstakingly studied the developmental patterns that are 'general' enough only within specific domains (Spelke, Mandler, Karmiloff-Smith, Gopnik, Hirschfeld, Gelman). A striking observation made by cognitive developmental psychologists who did ingenious experiments with infants in the crib was that quite a few concepts that were supposed by Piaget as products of a lengthy process of cognitive development were demonstrated to be either more or less innate or develop very soon after the post-natal ontogeny. Chomsky's and Fodor's rationalist philosophy forms a supportive framework of these studies dismissing empiricist, associationist and behaviorist beliefs on one hand and Piaget's (aka Kantian) empty schemas on the other. Most notable among these studies are those that demonstrate and argue that *language* is *instinctive* and peculiarly human.

In the last half-a-century, developments in computer science, particularly AI, have contributed several enlightening metaphors to cognitive science without which the discipline remains impoverished. The most significant contribution from AI has been in the area of knowledge representation and memory, drawing mostly from the centuries of deliberations on epistemology and logic. Today these remain the least controversial among the proposals on the architecture of mind based on the information processing approaches. Most notable and highly relevant to the current review are the concepts of *modularity* and *encapsulation*, borrowed from object oriented abstractions of procedural and declarative data modeling. Fodor's highly influential architecture of mind proposed that the mind is composed of peripheral (perceptual), domain-specific, dissociable functional sub-systems that are mandatory, swift, and involuntary processing units, wholly determined by evolutionarily selected genetic endowment. However, the high-level central cognitive systems that are involved in belief, creativity, reasoning etc., according to Fodor, are amodular and non-encapsulated. A group of scholars disagree with Fodor and attempt to modularize almost every cognitive faculty of mind making it massively (entirely) modular. In this context I will argue against the notion of informational encapsulation, by proposing that *cross-representation* of cognitive dimensions, which is impossible with encapsulation, is *essential* for the formation of concepts of any kind. Mandlers' observations suggest that percepts and concepts should be carefully distinguished. I shall further explain this distinction and the transformation of the former into latter using cross-representations. Further evidence from parallel distributed processing approaches used in simulating the process of concept formation, the traditional arguments of associationism, and the individuation argument, will be used support of this claim. The observations that prompted the hypothesis of informational encapsulation can be explained by invoking *selectively sensitive* sub-systems and/or anatomical constraints.

A leading developmental psychologist Karmiloff-Smith rather convincingly demonstrates that some behavioral (cognitive) modules actually are culminations of developmental process and not entirely innate. A brilliant theory of *representational redescription* (RR) was proposed by her to explain gradual and recurring reencoding of more or less inaccessible (encapsulated) implicit representations into explicit accessible representations leading to behavioral mastery. While Karmiloff-Smith's observation that modules must be culminations of a developmental process is reasonable, we need to distinguish between the modules that develop during embryogenesis (pre-natal ontogeny: **Layer 1**) and those that develop after birth (post-natal ontogeny). The former is ontologically and physiologically rooted in *biological* being, while the latter *cognitive* development is formal (relational), symbolic and epiphenomenal in nature. The post-natal cognitive development, I will argue, should be further differentiated into three layers: perceptual/conceptual (**Layer 2**), socially mediated folklore (**Layer 3**), and the counter-intuitive, rule based, explicitly constructed formal knowledge (**Layer 4**), the last two being peculiarly human. Most Fodorian modules (with the exception of the language module) are actually the *result* of pre-natal-embryogenesis, and not post-natal cognitive development. Though both pre and post-natal modules are part of the ontogeny of a single cognitive agent, they do not, so to speak, lie on the same path of development. In the case of human beings, the post-natal development is highly complex, making the distance between humans and apes almost unbridgeable. Karmiloff-Smith correctly argues that RR is peculiarly human. However, Fodorian modules and the peculiarly human behavioral 'modules' belong to different layers of ontogeny mediated by another layer of conceptual cognition. I will argue that RR occurs in post-conceptual ontogeny and not during the formation of conceptions. While holding that cognition is entirely biologically rooted,cognitive scientists must realize that biologically enabled 'social-physiology' as against biochemical neuro-physiology are distinguishable layers of ontogeny.

This brings us to the important question of what makes us peculiarly human. There are very few scholars who believe that cognition is only human, but it is often argued that the so called higher modes of cognition such as self-consciousness, theory of mind, fabrication of tools, language, scientific knowledge, etc., must be peculiar and defining characteristics of human nature. Very absorbing discussions of Daniel Dennet's levels of intentionality, Merlin Donald's three stages in the evolution of culture and cognition, and Peter Gardenfors's account of how Homo became Sapiens, provide a fruitful intellectual context to critically review the various proposals on this interesting question. The bundle of peculiarly human characteristics are strongly correlated to the social fabric of human life rather than genetic, neuro-physiological domain. Evidence is gradually accumulating to suggest that the larger size of human brain (encephalization) has mostly to do with the new found socio-cultural context during phylogeny. The fact that the genetic and anatomical differences between apes and humans is so marginal indicates that this problem is unlikely to be answered by gene and brain-centric view-points. Socialization and language go hand in hand, for they are not possible without each other. It seems therefore plausible to hypothesize that representational redescription is an *essential* mechanism in producing *external* memory space helping to enhance much needed memory capacity for storing cultural heritage, and also for *detached* processing of information: explaining thinking. Taking clues from Karmiloff-Smith and Merlin Donald, I think, it is possible to explain much of the peculiarly human features using this mechanism. Coherent with the above argument favoring a delineation of the biological development from the cognitive development, I shall argue that there are two *inter-dependent* but *superveniently* evolving inheritance mechanisms: biological and social. The nature of human beings cannot be understood without delineating the two. We have abundant evidence to support the point that the evolution of culture and higher forms of cognition are correlated.

Many leading cognitive psychologists (e.g., Alison Gopnik) today believe in a strong working hypothesis called: theory-theory. According to this view no knowledge worth the name can be non-theoretical, and the basic mechanism (or methodology) of knowledge formation and evaluation happens by theory change, and this mechanism is universal. By demonstrating that even infants in the crib are little theoreticians, they argue that the mechanism that makes us know the world around is the same as the one that makes science. While agreeing with them that there are general cognitive mechanisms (or methodologies), it is necessary to make certain finer distinctions which weaken the strong form of theory-theory. First of all, we need to make a clear distinction between conceptual and analogical: the former is a result of cross-representation while the latter is a result of *'across'-representation* drawing in similarities across domains based mostly on relational knowledge. Further, all theories are not of the same nature, particularly the model driven, counter-intuitive scientific theories. While folklore is also sufficiently theoretical (analogical) and non-inductive, a form of knowledge belonging to another layer of cognitive ontogeny—mostly but not necessarily identical to scientific—can be clearly distinguished: let us call this *formal*. Formal knowledge is an *explicitly constructed* form of knowledge in the sense that the rules of construction are overtly specified. This form of possible world construction creates an idealized description of the actual world that describes indirectly (mediated by models) the phenomenal world. Only in this form of construction can we find *invariant relativistic descriptions* of various flavors of scientific theories. Contrary to the claims of theory-theory proponents, I suggest that transformation from the cognitive layer of folklore to explicitly constructed knowledge cannot happen without formal instruction, necessitating social institutions like schools. This argument, if it is valid, can have profound practical implications in the context of science education. Needless to say, my position goes against the views in philosophy of science that theory-theory finds support in.

The four layers of cognitive ontogeny, that helped us to critically appraise the current popular models of cognition, clearly correspond to developmental *stages*, but are not strictly identical to Piaget's. Firstly, cognitive development is supervenient on the physical development, and not a continuation of the same line of development. Secondly, the layers are distinguished by a bundle of features that go hand in hand and are not strictly age-dependent and may happen in different phases in each domain depending on environmental pressures. Thirdly, the four layers recapitulate phylogeny supporting Piaget's claim of cognitive version of biogenetic principle.

Based on the above critical exposition, a few comments I think are in order on the perspectives and prospects of cognitive science. While arguing against the behaviorist model we tended to be excessively 'inward' looking in our search to describe human nature. If my arguments have any weight, we should be looking mostly at what is publicly accessible to understand what is peculiarly human. This reminds us of one of the most brilliant philosophical arguments in the history of philosophy: Wittgenstein's private language argument, where he argued against the possibility of private representations. Neuro-physiology can inform us of the manner of encoding episodic memory, but possibly none of semantic memory, an essential form of human cognition. It is highly likely that semantic memory is stored exclusively in the externalized public socio-cultural mind-space. Scientific knowledge is necessarily and undoubtedly located in the inter-subjective space. A few of our scientists have 'gut' reactions against science having a socio-cultural foundation. But, I think, this does not by any means make it less objective, since externalizing by reencoding is the only means of making private subjective knowledge public and potentially objective. By interpreting Wittgenstein's argument as it applies only to semantic memory and not episodic, I suggest a transformation mechanism in terms of representational redescription, which explains one of the mechanisms involved in learning and discovery. A cogent and complete understanding of learning and discovery cannot be accomplished without responding to Wittgenstein's challenge.

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The Challenge of Knowledge Soup

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People have a natural desire to organize, classify, label, and define the things, events, and patterns of their daily lives. But their best-laid plans are overwhelmed by the inevitable change, growth, innovation, progress, evolution, diversity, and entropy. When the Académie Française attempted to legislate the vocabulary and definitions of the French language, their efforts were undermined by uncontrollable developments: rapid growth of slang that is never sanctioned by the authorities, and wholesale borrowing of words from English, the world's fastest growing language. In Japan, the pace of innovation and borrowing has been so rapid that the older generation of Japanese can no longer read their daily newspapers. These rapid changes, which create difficulties for people, are far more disruptive for the fragile databases and knowledge bases in computer systems. The term _knowledge soup_ better characterizes the fluid, dynamically changing nature of the information that people acquire, reason about, act upon, and communicate. This talk addresses the complexity of the knowledge soup, the problems it poses for intelligent systems, and the methods for managing it. The most important measure for any intelligent system is its flexibility in accommodating and making sense of the knowledge soup.

Trends in Mathematics Education Research: The Example of Algebra Education

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In this lecture, I will survey some recent trends in mathematics education, by examining the evolution of the study of the teaching and learning of algebra. Even though the field of research in mathematics education is small by comparison with the major disciplines in science and the humanities, it is now too large to make strong claims about trends and findings, so a narrowing is essential. Algebra education is a good choice because it has been a particularly active field and I can draw on the outcomes of the recent 12th ICMI study on "The Future of the Teaching and Learning of Algebra" (see Stacey, Chick & Kendal, 2004 and Chick, Stacey, Vincent & Vincent, 2001) where many of the world's leading algebra educators worked together to identify major trends and consider the way forward. More importantly, algebra education is a good choice because many of the major concerns of mathematics education as a whole also impact on algebra education.

I see mathematics education as essentially a practical discipline, where the underlying goal is always to promote better learning of mathematics by students. Of course there are many subtleties of what mathematics should be learned and why, in whose interest is it that students learn, how achievement is measured etc, but the discipline of mathematics education is underpinned by a faith that a good education in mathematics benefits both the individual and society. These benefits include shared values (e.g. empowerment of the individual, the value of logical thought, etc) as well as practical outcomes such as the support of scientific and business endeavours.

Mathematics education is an interesting discipline because it draws on many other fields of study. To answer its central question of "how to teach mathematics better" requires understandings from many other disciplines (e.g. psychology, human development, sociology, mathematics, philosophy and epistemology) and many areas of general education (pedagogy, curriculum studies, policy, etc). All of these are also relevant to algebra education. Mathematics education also draws its research methods from these and other disciplines, and the need to take stock of the plethora of approaches is an ongoing area of concern. The status of the findings in mathematics education is mixed. Some results describe in a very deep way the basic interaction of the human brain and mathematical ideas. These results are likely to be observable in any society and across time. As the oldest human study, stretching back millennia, mathematics retains an identifiable core of fundamental processes by which it is developed. One example particularly relevant to algebra is the way in which many concepts have their roots in actions and processes, which become encapsulated as mathematical objects. We see these changes in students' growing conceptions (e.g. of algebraic functions) and we know that teaching needs to ease such transitions. After three decades of work identifying some of these fundamental processes, algebra education can now go forward on a strong base. At the other extreme, some findings of mathematics education are insightful and important, but are mostly relevant to a particular situation at a particular time. Studies of the impact of the recent changes to the algebra curriculum in some Western countries, where traditional manipulation was suddenly markedly reduced, are like this. Much of the best research has something to say of immediate interest, as well as contributing lasting insights.

Trends in algebra education research, like other areas of mathematics education, are influenced by factors external and internal to the field. A group of external factors have led to the "massification" of secondary school education, whereby it is now the norm in many countries, that most students complete secondary education, and this education includes algebra. Algebra is seen as a "gateway" to higher mathematics, because it provides the language in which generalisations are expressed. Consequently, having students learn algebra is important for the production of "knowledge-workers" as well as being important for social equity. But algebra is difficult, and instead of being a gateway, it can easily be a wall that blocks students' paths. This leads to a reconsideration of the goals of algebra, to identify what are its essential components and to a search for improved teaching methods. Traditionally, algebra had been mainly seen as symbol manipulation, but most graduates of such curricula have no appreciation of why this knowledge is important. Ongoing reconceptualisation of the core of algebra has, for example, elevated the importance of graphs and functions, at the expense of solving and rearranging expressions. The ability to deal with graphs and a basic concept of function are more likely to be seen as "basic" now than moderately complicated symbolic manipulation. The new technologies have also impinged very strongly on algebra education research. As communication technologies, these impact on all of education (e.g. distance learning, data from the internet, new means of presentation etc). But as information technologies, these impact centrally on the way in which mathematics is done. Mathematics at every level, from the work of the shopkeeper to the mathematician, has always struggled to make calculations easier, and we now have tools that can perform all of the standard routines known by an undergraduate at the press of a button. This provides exciting new opportunities for teaching, especially through the possibilities of teaching with multiple representations of algebraic ideas. It also provides a serious challenge to existing curriculum: what is the role of the machine and what is the role of pencil-and-paper skill? To answer this question, we need to be very clear about goals for algebra education, about what it means to understand and to develop new pedagogies to meet the new situation.

Algebra education research is also impacted by trends that are internal to the educational research community. At a simple level, the growth in international exchange has opened up appreciation of the possibilities for curriculum, teaching and assessment. Algebra education was perceived as something common around the world, but the differences are now known to be large on all dimensions - the degree of formalism, the amount of manipulation, the place of functional thinking, the use of technology, the age of introduction etc. There are many alternative successful approaches.

Important intellectual movements from other disciplines also impact on algebra education. For example, studying the history of mathematical ideas has led to the identification of particular cognitive obstacles for students (e.g. related to the ways in which letters are used), and consequently to teaching approaches that assist students cross the barriers. On a more theoretical level, the role of algebra as "the language of mathematics" has been studied from the point of view of semiotics (the science of symbols) and linguistics (the science of language).

Research into algebra education is a lively field, aiming to engage with social needs and intellectual advances. However, its success should be judged by the extent to which it can promote algebra as a lively, engaging and worthwhile subject for an increasingly large number of students.

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Trends in Science Education Research

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This presentation will examine some of the unprecedented developments in science education research in the past three decades (1974-2004).

In the last 30 years, there has been a huge increase in international professional research activities (as is illustrated by this conference), resulting in an increased output of publications in science education research from a wider range of nations (as is illustrated by the number of new journals, especially in the English language), and an increased amount of professional development initiatives (as is illustrated by increasing interactions of professional societies, employers and universities and the growing importance of the roles of science teachers' associations in many countries).

At the classroom level throughout the past 30 years, there has been a constant call for more relevant science education (as is illustrated by a growing interest in post-compulsory schooling and how to provide appropriate curricula and assessment in science education) and for greater inclusivity in science education (as is illustrated by the need for science curricula that do not simply reflect social and cultural stereotypes of science).

During this period, there has developed a great diversity of the types of research being conducted in science education. At one end of this spectrum are large-scale assessment programs (as is illustrated by the Trends in Mathematics and Science Studies (TIMSS) and the Program for International Student Assessment (PISA) studies which provide both national data and international comparisons). At the other end of this spectrum are small-scale studies of the work of science teachers in individual classrooms (as is illustrated by action research studies and the detailed documentation of expert practices). To be able to conduct studies of this range, over the past three decades, there has been an increasing acceptance of alternative genres of science education research and an acknowledgment of their own strengths and weaknesses.

This presentation will expand upon the issues described above with examples from different countries. However, from my perspective, despite all the developments in science education curricula, assessment and research, there is still need for a greater understanding of the relationships between policy and practice and a realistic expectation of what science education research can contribute to practice. This certainly should be a major part of the work of science educators in the next three decades.

Trends in Technology Education Research

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The concept of 'Didactics'

In the Routledge International Companion for Education a separate chapter was dedicated to 'didactics'. The author, Gundem, explained that the term 'didactics' in the Anglo-Saxon language countries has a negative connotation, because it indicates rigid prescriptions for teaching. But in other languages, such as French and German it has a much more positive meaning. 'Didactique' or 'Didaktik' stands for the systematic and scientific reflection on teaching practice, leading to knowledge that can be used for teachers to improve teaching and learning. Teachers see 'didactics' as a natural component in their training and try to apply in their work, and the research community has accepted it as a serious research field for many school subjects. In physics education in the Netherlands teachers have often been involved in research projects. Those projects were often a combination of research and development work (in business circles this would be indicated as R&D). So it appears to be possible to give content to such a concept as 'Didaktik', 'didactiek' or 'didactique' or whatever it may be called (from now on the term 'didactics' will be used, but the reader should keep in mind that this is not meant in the Anglo-Saxon mode). The idea of this concept is that 'didactics' provides a scientific basis for teaching. This should be reflected in the research agenda for 'didactics'.

The agenda of 'didactics'

The agenda of 'didactics' should reflect the needs of teachers, as researchers should address them. Gundem presented such an agenda. In this paper that agenda has been adapted to become the following:

(1) What are goals and contents for teaching (and why are these to be regarded as such)?

(2) To whom (pupils and students) and by whom (teachers) is this content taught? What are their characteristics (knowledge, experience, attitudes, etc.)?

(3) How can teaching-and-learning situations be reali-sed to pass on the identified content (see 1 below) to the identified target group by the identified people (see 2 below)?

Several authors have stated a desirable research agenda for technology education. Although differently phrased, their ideas do not differ fundamentally. In fact they present a research elaboration of the 'didactics' agenda as has been used in this paper that can be summarised as follows:

(1) What and why to teach and learn about technology?

- Who defines goals for technology education and what goals are defined?
- How can technological literacy as a goal for technology education be defined?
- What is the nature and role of knowledge and creativity in technology education?

(2) To whom and by whom to teach and learn about technology?

- Who participates in technology education (e.g. pupils, students, and teachers)?
- What are their preconceptions and concepts of technology?
- What subcultures are there (e.g. genders)?

(3) How to teach and learn about technology?

- How was technology taught in the past and in what context?
- How do curriculum changes take place?
- How does curriculum integration take place (relate technology to other school subjects and to the outside world)?

This list only partially coincides with the list of important issues for technology education that Wicklein and Hill found among teachers and teacher educators. They mention: funding, academic content, program vitality (position in the school curriculum), leadership, research as a basis for teaching practice, teacher supply, identity of technology education, and integration in the total school curriculum. Of these issues some appear in the research agenda that was based on Lewis and Petrina, but some do not. Evidently there is a difference between what researchers and what teachers see and relevant issues for technology education. Only when researchers and practitioners (teachers) can agree on research topics, a fruitful transfer from research to practice will become feasible. In this paper the research side will be explored: what issues were covered in actual research studies? An analysis will be offered that focuses on the extent to which the agenda of 'didactics' has been addressed in the research practice of the past decade or so. Then we can compare this with the issues that were mentioned as relevant by teachers.

The outcomes show that the field of curriculum goals and content (the 'what and why') is well covered in the research base that we have investigated. Much less attention has been paid to the field of the teachers' and learners' characteristics (the 'by and to whom'). More than expected from the previous analyses by Zuga and Petrina the field of educational practices (the 'how') was addressed in the research base. Many of the topics in each of the fields at first sight seem to be relevant for teachers and relate to the topics that they themselves mentioned in the survey by Wicklein and Hill: academic content, identity of the subject, integration in the school curriculum, and in 2 articles the research as a basis for teaching practice. But in all fields the outcomes are often presented in such a way that teachers are not directly challenged for action. Some of the topics that were mentioned as relevant for educational practice by teachers themselves do not seem to have been addressed at all (funding, program vitality, leadership and teacher supply in the list that Wicklein and Hill found). So the tension between researchers' and teachers' interest that was already expected when we surveyed the 'didactics' research agenda, was confirmed by the analysis.

Student and Teacher Related Variables as Determinants of Secondary School Students' Academic Achievement in Chemistry in Lagos State, Nigeria

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Objectives of the Study

The study aimed at constructing and testing a model for providing causal explanations of secondary school achievements in chemistry in terms of student variables – gender, study habit, mathematical ability and teacher variables – gender, age, qualification and year of experience. Based on the objective, the study attempts to provide answers to the following questions:

1. What is the most meaningful causal model for students' achievement in chemistry?

2. What are the directions as well as estimate of the strengths of the causal path (Path coefficients) of the various variables in the model?

3. What are the direct and indirect effects of the independent variables on achievement in chemistry?

4. What are the composite and relative contributions of the seven independent variables ($X_1 – X_7$) to the prediction of students' academic achievement (X_8)?

Significance of the Study

The study would throw more light into the causal relationships between the student and teacher related variables under investigation and achievement of students in chemistry. The outcome of the study is therefore expected to assist all stakeholders in the teaching of chemistry particularly at the senior secondary school level, to fashion out appropriate strategies that would enhance the teaching and learning of the subject.

Underlying theoretical framework

The focus of the study is hinged on teacher and student; therefore, theories that have to do with the characteristics of both of them as they affect learning would be applicable. Students are at the center of learning because it is the belief of the authors that teacher cannot control learning, which is the prerogative of the student. He can only control his teaching. This claim supports constructivist's view that learners are actively engaged in making meaning and in the construction of ideas. And this could be said to be affected by variables that have to do with them; these include, gender, study habit and mathematical ability that are considered in the study.

The theories of Piaget, Ausubel, and Gagne would therefore provide theoretical basis for the study.

Research design

An ex – post facto research design was adopted for the study. This was because there was no manipulation of independent variables.

Procedure

The population for the study was made up of all senior secondary school year two students and their teachers in Epe and Ibeju-Lekki, local government areas of Lagos state. Six and four schools were used in Epe and Ibeju-Lekki local government respectively. A total of two hundred and one students were used in the selected schools. All chemistry teachers in the selected schools took part in the study. The four instruments used for data collection were: (i) Personal Data Questionnaire for Teachers (PDQT) (ii) Study Habit Inventory (SHI) (iii) Mathematical Ability Test (MAT) and (iv) Chemistry Achievement Test (CAT). The administration and collection of all the necessary information were done during the normal class periods. Multiple regression and path analysis were employed to analyze the data.

The hypothesized model was initially designed based on the three factors for generating the causal model according to Blalock (1964) Duncan (1966), Bryant and Doran (1977). These are, temporal order, research findings and theoretical grounds.

Findings

The results revealed that 7.6% ($R^2 = 0.076$) of the total variation in students' achievement was accounted for by the seven independent variables. Thirteen out of the eighteen paths in the hypothesized model were found to be significant at 0.05 levels. This resulted in trimming and consequently, the production of the parsimonious causal model. It was also detected that the significant paths through which the independent variables caused variation in the dependent variable are four, and they are all direct paths. However, 5.82% of the total effects are found to be direct.

Teacher's age has a significant causal effect on students' achievement in chemistry. The direct effect accounts for 4.40%, which is the highest of the total effect of all the seven independent variables. Teacher qualification has the second most potent causal influence on students' achievement in chemistry. Its direct effect accounted for 4.37% of the total effect whereas its indirect effect accounted for 5.0%. Thus, altogether, teacher qualification accounted for 0.63% of the total effect of the seven independent variables on students' achievement. Teacher experience also has significant causal effect on students' achievement. The direct effect accounted for 3.46% of the total effect of all the variables. Its indirect effect accounted for 0.12% of the total effect. Altogether, teacher experience (X_4) accounted for 3.58% of the total effect of the seven independent variables on students' achievement. The variable also significantly affected student study habit. Teacher gender was found to have direct effect on students' achievement in chemistry. Its direct effect accounted for 0.97% of the total effect of the seven variables whereas its indirect effect accounted for 3.37% of the total effect. Thus, altogether, teacher gender accounted for 2.40% of the total effect of the independent variables.

Furthermore, the study revealed that the student variables- gender (X_5), study habit (X_6) and mathematical ability (X_7) had no direct and indirect effect on academic achievement in chemistry. This is not to say that they did not have effect but their effects are not significant particularly in the presence of the teacher variables. This finding established the importance of teacher in a teaching – learning situation.

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Teachers and Students' Ideas about Sociology of Science: A Study at the Level of Primary School

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Scientists do not work isolated in boxes hermetically closed from the external environment, or develop their ideas detached from the scientific community (or even from the non-scientific one) to which they belong. But what is the role of the community, of the society direct or indirectly related to science, in the development of the scientific ideas? How are the scientific ideas influenced by social/political/economical contexts? While the historians and the sociologists of science try to answer these questions the pedagogues wonder about how to explore these aspects in the classroom in order to provide students an enlarged, embraced and closed sight of what the science really is and how is it built and developed.

The conceptual framework in which studies about school science ideas are supported – more exactly, the ideas of science, scientist and scientific work developed by students, teachers and school curriculum – are predominantly based on psychological and epistemological principles. So, we attempt to contribute to the decrease of this hiatus by enriching the investigation with theoretical framework from sociology. The study is mainly based upon Bernstein's theory (1999, 2000), that gives the concepts of *classification* and *framing* to the analysis and data interpretation.

This study aimed to recognize and understand the ideas that teachers and students of primary school have about the different aspects of sociology of science which will allow us, to ponder about *what* and *how* can we explore such aspects in teachers' education and children's learning process in order to promote a deeper and realistic sight of the scientific enterprise.

The pattern we selected to this study was of about twenty teachers of elementary school, with different professional experience and twenty-four students attending the 4th grade (seven girls and seventeen boys), aged between nine and ten.

The teachers answered a multiple choice questionnaire with 40 questions. They had to select one option out of four: TD (Totally Disagree), Disagree (Disagree), A (Agree), TA (Totally Agree). The students answered a questionnaire with two parts, one of open questions and the other with 20 questions of multiple choices. The students had to choose one out of three options: D (Disagree), A (Agree), NT (Not know) Afterwards eight students were selected out of twenty-four to answer a semi-structured interview with similar topics. There were four boys and four girls of different social background. Some of them belonged to low social class and others to upper social class. During the interview students were shown several pictures about various scientific activities to which they were stimulated to comment.

The topics of the questionnaires and interviews were similar both to teachers and to students. They were as follows: (a) The influence of social, political and economical contexts in the development of science; (b) The existence of scientific communities and their characteristics; (c) The influence of the social group – social class, race, gender, country of origin... – in the scientists' status and credibility; (d) The existence of consensus and confrontation of beliefs between scientists and scientific communities; (e) Relationship between scientific communities and validation of knowledge.

Regarding the teachers, the results show that in a general way, although they consider that social, cultural, political and economical contexts influence the development of science and that the science is a social and communitarian enterprise, they do not clearly realize the way these communities work, investigate, influence and communicate among themselves. By and large, they also consider that the science is free of prejudice... once they state that there are equal opportunities and success in their career beyond the social group (gender, class, nationality...) of the scientists. The teachers still show confused thoughts about the existence or not of consensus and/or conflicts of beliefs between scientists and scientific communities.

Regarding the pupils, the results suggest perspectives of the scientific enterprise far from the reality. They uphold by and large, that the social, political and economical contexts in which the science is absorbed do not interfere in their course; they also uphold that the scientists'social group does not influence their status and the access to investigation and scientific knowledge. Although the pupils declare that the scientists work mainly in a group and that the organization of group work is vital they show vague and unclear thoughts on the way these groups are organized and work. The pupils also consider that in science there is often a consensus of thoughts between the scientists and the scientific communities what seems to reveal a perspective of "normal science" and not so much of "revolutionary science". The results of the interviews brought awareness of a new fact. Through the interview we realized that boys have a more fanciful idea of science than girls. The boys emphasize the possibility of "great discoveries", "great inventions", " problem solving through science"...; on the other hand, the students of the upper class show closer ideas of what science is than the lower class ones. Students' gender and social class seem to constitute variable mediators of the view of science.

The continuities and discontinuities/cleavages between science ideas presented by teachers need to be pondered once they interfere in the way they develop their teaching and pedagogical practice, how they plan the experimental work and implement the curriculum... in short in the way they help to build students' beliefs.

In conclusion, the study gives suggestions about how the view of "conceived science" can approach to "real science".

Keywords: Science curriculum; nature of science; sociology of science; scientific community.

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Students' Explanations: A Review of How Students Understand the Theory of Evolution

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The abundance of varying life forms, and their abilities to survive in equally varied circumstances, becomes meaningful in the light of the theory of evolution. Naturally then, one of the often-used ways to diagnose students' understanding of the theory of evolution is to elicit and analyse their explanations of relevant phenomena. Around early nineteen eighties, science educationists interested in "children's science called a similar approach as "interview-about-events (e.g. 8)

In the conference that aims to review research in various branches and roots of science education, it would be appropriate to review research on the students' explanations of phenomena in the domain of theory of evolution. The review will be organised around the major principles –variation and natural selection (random or "blind heritable variations, differential reproductive success in specific environments and consequent changes in population structure/speciation etc.) – of the theory of evolution (5); and what the students tell us about their understanding of these principles (1-4, 6, 7, 9-13, 15-19). This review thus intends to put the scientific explanations vis-à-vis students' explanations, and to present our interpretation of students' understanding of the phenomena. The observations are grounded in the current literature but more empirical and theoretical explorations are necessary for a clearer picture.

Students "see the *variation* as a result of altered environmental condition. Thus, for most of the students, variation does not *precede* environmental change but *follows* it. Here, environment or "nature is playing *instructive* rather than *selective* role. The cruciality of already-available-variations contributing to the survival in a now-different environment is generally not recognised by the students. In other words, they do not understand that evolution of the species is a "variational evolution (12). Evolution, for them, is a consequence of the intrinsic drive of organisms to survive in the face of challenging environments; it is for them a "developmental or transformational evolution – transformation of un- or less "adapted organisms or "species into the "adapted ones. In a sense then, they perceive the "need to adapt as a *cause* of evolution; adaptation, for majority of the students, is not the *effect* of natural selection over many generations. So, for many students, organisms or species-as-a-unit are adapting. Their pre-scientific explanations do not involve the concept of "changing populations of individuals, each one having "unique constellation of characteristics (many of these common among the conspecific individuals) (14). Students most probably fail to correctly disentangle various levels of biological organisation that vary continuously in the process of evolution: molecular/cellular (the source of variation), organismic (individuals that vary and, if successful, reproduce), populational (can change over many generations due to differential survival), and (rest of the varying) environmental level. Each of these levels has its own dimension of time, ranging from generation time to geological time. It is difficult to understand and appreciate – for students as well as for many of us – that, the evolution is, in Lewontin's words, the conversion of the variation among individuals within an interbreeding group into variation between groups in space and time (12).

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Action-based Science Education for Health and Environment

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India's attempts to industrialise and become a developed country have led to a heavy burden of diseases, both communicable and non-communicable. India loses about 292 million Disability-Adjusted Life Year (DALY) against 201 DALY loss in China. In other words, an average Indian loses 63 Disability-Adjusted Life Days (DALD) per year due to communicable diseases, as against 16, 5, and 4 DALD loss in China, Former Socialist Countries (FSC) and More Developed Countries (MDC), respectively. These communicable diseases are closely linked to our environment.

Homi Bhabha Centre for Science Education (HBCSE) has a broad objective of improving science education in the country. The Centre carries out a variety of activities at different levels to achieve its goal of equity and excellence in education. The Health Education Programme of HBCSE (1993-1997) attempted to find out students' understanding about different aspects of health. The results showed that students had 'poor' understanding of genetics, nutrition and social factors, which affect health. Further probing revealed that though students were aware about microorganisms as causative agents of diseases, they were unaware of the different environmental reservoirs and their role in disease-transmission. Considering the heavy disease-burden in India, on one hand, and the fast deteriorating environment, on the other, a more proactive educational approach was recommended to be followed in our school and college curricula.

Health and Environment Action-based Learning (HEAL) is a new educational initiative of HBCSE, with the potential to sensitize large number of students about their immediate environment and its effect on health. HEAL coordinators have put together relevant theoretical information, experimental protocols and data sheets in a comprehensive Protocol Guide. This Guide enables students to carry out detailed studies, experiments and observations of different environmental parameters (air, water, soil, green-cover and waste) and symptom-based health surveys, yielding provisional diagnosis of environment related health problems

For the execution of HEAL, HBCSE is collorating with the National Service Scheme (NSS) unit of the Mumbai University. A large number of students (~1000) along with their teachers from five colleges of Navi Mumbai are involved in collecting data for various environmental parameters, followed by health surveys. This study will be carried out seasonally (three times in a year, i.e. pre-monsoon, post-monsoon and winter) in different nodes of Navi Mumbai, covering an area of 79.24 sq. kms.

The programme is executed as follows:

HBCSE scientists and other resource persons train NSS teacher co-ordinators.

Trained teachers guide the participating NSS students to carry out the study at their allotted study site.

Students perform experiments, surveys, carry out analysis and prepare a final report of the observed results.

These results are validated by HBCSE scientists and from records supplied by the Navi Mumbai Municipal Corporation.

HEAL: Pilot Study (December 2003)

HEAL was initiated in 2003 with a pilot study confined to an area of ~ 0.18 sq. kms (Sector 9 of Vashi, Navi Mumbai). *Air quality* was studied at different sites (residential and commercial) using a high volume dust sampler. *Drinking water quality* was analysed chemically and microbiologically (MPN count: Most Probable Number, which is an indication of the presence of coli forms). The *soil* of the study area was also analysed for its physical and chemical properties. *Green cover, solid domestic waste and health studies* were carried out as per the guidelines given in the Protocol Guide.

This study, though limited in nature, showed some interesting results:

High levels of particulate matter {Suspended Particulate Matter, SPM (>10mm) and Respirable Particulate Matter, RSPM (<10mm)} were accompanied by high incidence of the upper respiratory tract problems in the surveyed area.

The green cover in the planned gardens, which were well maintained, was about 40-58%.

Residents did not segregate domestic solid waste. Ill-equipped rag pickers carried out the same with expertise and were well aware of the risks involved, including that of AIDS.

Only five medical set-ups out of 16 in the study area were segregating medical waste.

Presence of large number of stray dogs was a strong indicator of non-scientific management of waste in the area.

Malaria is prevalent in the area of Navi Mumbai. The overall observations of the houses and house lane surroundings revealed a clean environment, though mosquito larvae were observed in water containers in about 10% of houses.

HEAL: Annual Seasonal Study (September 2004)

Equipped with the pilot study experience, a large-scale seasonal study, involving nearly one thousand NSS students, is now underway (2004-2005) in five nodes of Navi Mumbai (Vashi, Turbe, Koparkhairne, Airoli, Nerul). The preliminary results of the first seasonal study largely confirm the trends of the pilot study, especially in the context of high levels of particulates and incidence of upper respiratory tract problems. The green cover greatly varied in different zones, and the open water bodies were largely unpolluted and well maintained.

Educational Implications of HEAL

HEAL has the potential to sensitise a large number of students about the important and complex issues of health and environment. The hope is that the students will reflect and imbibe scientific knowledge about these issues, so essential for our survival.

HEAL emphasizes hands-on experience. Use of different scientific methods, involving experiments, fieldwork, graph making and analysis of their results, exposes students to the intricacies of science.

HEAL takes scientific knowledge to the common people, thus 'bridging the *know-do gap*' — knowledge leading to action/doing.

Students' understanding of different scientific concepts (pH, dilutions, solubility, settling velocities of particulates, microorganisms and their reservoirs, plant diversity, to name only a few) in several disciplines is clarified with their experiences in the field and in the laboratory.

HEAL provides an opportunity to generate time-series data for different environmental parameters and health status of people in a study site. This inculcates the culture of data collection and analysis in our young students. Simultaneously, the data could have implications for policy changes.

HEAL is a multi-disciplinary programme. The participating students soon realize the many perspectives/dimensions involved in health and environment.

The study gives a true picture of complexities in the context of both environment and health, as it exists at the ground level. Thus the students are exposed to real life situations where science can be directly applied.

HEAL with its scientific analysis provokes students to think of alternatives/ possible solutions to the present health and environment problems in their respective areas.

HEAL encourages students to adopt sustainable development methods in their homes, localities and colleges. It is hoped that HEAL can help in the efforts to prevent further deterioration of our environment and reduce the related disease-burden.

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Students' Understanding of DNA and DNA Technologies after "Fifty Years of DNA Double Helix"

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Introduction

The 20th century saw rapid strides in the science of genetics, especially after the discovery of the structure of DNA molecule, giving rise to new disciplines/areas of work. Besides improving our conceptual understanding of the hereditary molecule and related processes, applications/technologies of genetics are common and manifold today. The year 2003 saw major celebrations on "Fifty years of DNA Double Helix".

Both the academic and industrial world realize the power and importance of genetic technologies. The recombinant DNA technology has introduced new products, like genetically modified organisms (GMOs), to be introduced in agriculture and pharmaceutical industry. Several of these have already reached the Indian markets. The fast development of GMOs, along with the success of animal cloning and data generated by the Human Genome Project have thrown up several ethical, legal and social issues (ELSI) about the widespread use and growth of these technologies. To understand these issues and for informed popular participation in the decision making process for their introduction and use, we need to have a scientific literate population.

With this perspective, a preliminary study was initiated in two cities of the country, in Mumbai and in Shillong, Megalaya. The attempt was to examine students' understanding of the structure of DNA, genes and other related concepts and DNA technologies, including questions about the GMOs, among undergraduate students. So far, to the best of our knowledge, such studies are uncommon in India. An open-ended questionnaire of twenty questions was given to students of biotechnology and microbiology, who are supposed to be well versed in genetics and biotechnology. Analysis of the responses of Mumbai students is given below.

In brief, only about 20-30% students showed scientifically correct understanding about the details of the genetic molecule, or about the structure and function of the gene; their understanding about the many genetic technologies, like cloning and DNA fingerprinting was also poor. Students seemed to be aware about GMOs and their introduction in India, including that of Bt cotton, which often finds wide newspaper coverage. Only 9% of students gave reasons for introduction of GMOs in India.

Results and Discussion: The questions covered a wide range of topics in modern genetics, starting from the structure of DNA molecule, the structure and function of genes, to some genetic technologies and ending with the introduction of genetically modified plants/organisms (GMOs) in India.

The important findings of the study are:

1. A large majority (87%) of students were aware that Watson and Crick had elucidated the structure of the DNA molecule, but only 18% gave the correct year of this discovery. In other words, these students seemed to be unaware of the "Fifty years of the DNA double helix".

2. Students had a general idea about the DNA structure, but large numbers did not know the details of the structure (width and length of DNA per turn), number of base pairs per turn, types of bonds involved in the structure and the details of the complementary nature of the molecule.

Structural details of ß DNA	Completely correct response	Incorrect/Partly correct response	Not attempted
No. of strands	84%	6%	10%
Chemical composition	39%	49%	12%
Types of bonds	10%	84%	6%
Specific dimensions	14%	49%	37%
Complementary nature	47%	53%	

3. The questions about gene structure and function revealed that the majority (78%) have a scientifically incorrect understanding of the molecular concept of the gene, though 45% could explain the concept of central dogma in the form of a correct flow chart and

30% stated that genes are involved in protein synthesis.

4. It was also observed that only 35% students could further scientifically elaborate on the concept of gene function when extrapolated to a real life situation. Again, large numbers did mention that the blood disorder was linked to genes, but they could not establish links between the defective gene and the defective protein (in this instance, defective hemoglobin molecule leading to thalassaemia).

5. Regarding other gene functions besides protein synthesis, only 4% students mentioned the role of genes in the synthesis of other RNAs.

Apparently, students seemed to be guided by the contents in biology textbooks, but were unable to extend this information to situations outside the texts. The concept of the gene has kept on changing with advances in genetics. From a Mendelian interpretation of the gene as a "…discrete unit of inheritance", the concept has transformed into its today's molecular interpretation, involving "…the segment of DNA involved in producing a polypeptide chain; it includes regions preceding and following the coding region (leader and trailer) as well as intervening sequence (intron) between individual coding segments (exons)." In addition, the molecular definition of gene could include "…the DNA which is transcribed into rRNA, tRNA and other RNAs, not translated into polypeptides". Students were unable to synthesize these pieces of information about the gene structure into a coherent definition.

6. Overall, the students' understanding about the details of different genetic technologies —cloning, sequencing, fingerprinting — was poor. They seem to be confused between DNA sequencing and DNA fingerprinting. For instance, the basic concept of DNA fingerprinting, the search for differences in polymorphic regions of DNA, was missed out by them. On the other hand, they knew the applications of these technologies.

7. More upsetting, students in large numbers (66%) did not have any idea about the human genome project or its impact on our lives.

8. The last set of questions focused on finding out students' ideas about the introduction of genetically modified organisms (GMOs), including plants, in India. This point is becoming a highly contentious issue in the country involving different stakeholders like regulatory agencies, scientists, farmers, industrialists, consumers and a variety of non-governmental organizations. Often based on misinformation, the issues tend to lose sight of scientific facts and assume highly polemic/ polarized positions. In this context, it was interesting to find out as to how biology students think of GMOs and their introduction in India.

Our results revealed that only 58% students had heard about GMOs and still fewer could give the full form of GMOs. Nine per cent knew the technical details involved in their production and 27% were aware about the introduction of Bt cotton in India, which is the only genetically engineered plant introduced so far in the country.

Students seemed to be enthusiastic about the introduction of GM plants in the country, but they emphasized on strict regulations to be followed before their introduction. Matured arguments were put forth by both the groups of students, those who were in favor or against the introduction of GM plants in India. While some talked about the higher yield or the protection from pests and low use of pesticides with these modified plants, others talked about loss of natural biodiversity and the overall threats to the environment in future.

A few students (9/108) gave accurate details of the regulations which need to be followed before these plants are introduced in the country. They talked about checking the so -called advantages of GM plants in all climatic and soil zones of the country, checking the side effects, if any, of food plants, possible production of toxins and the passage of latter into insects and other components of the environment, etc. This level of sophisticated thinking was impressive.

Our study, though preliminary in nature, revealed that students' understanding about genetics and related concepts, along with their understanding of the GMOs, needs considerable strengthening.

Professional Development of K-12 Science Teachers: History of Reform and Effects of a Science-Technology-Society (STS) Approach in Bringing About the Reform

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Professional Development: Need and Role in Science Education Reform

Several recent science education reform efforts around the world (for example, Project 2061, American Association for the Advancement of Science, 1994; Millar & Osborne, 1998) reflect a common concern for providing science education that is relevant to the lives of all students. Achieving such reform is a complicated task that includes providing specific professional development opportunities to teachers. Traditional 'in-service days' as the norm in professional development has been criticized as inadequate and inappropriate in the context of current educational reform efforts, and as being out of step with current research about teacher learning (Darling-Hammond & McLaughlin, 1995). A new perspective on professional development of teachers has become a crucial first step in the reform process. Lieberman (1995, p. 592) notes, "The conventional view of staff development as a transferable package of knowledge to be distributed to teachers in bite-sized pieces needs radical rethinking."

Making science relevant to the lives of students requires, among a variety of other factors, a classroom environment in which the students can be actively involved in making meaning of the information within a relevant context. Teachers need to learn to create a suitable instructional environment and employ strategies that encourage active questioning and identification of issues and answers by students. They need to be able to encourage students to challenge the information presented and discuss its personal relevance. Development of these abilities require carefully designed, sustained, long-term professional development opportunities that actively involve teachers in the learning process.

Professional Development or In-service Education: What's the Difference?

Staff development activities have traditionally been packaged into short-term, discrete, in-service sessions or workshops. Most of these workshops tend to follow a somewhat standardized format-an outside expert (or consultant) 'blows in, blows up, and blows out' while teachers are expected to passively receive whatever was 'blown up' and try to make use of it in their teaching practice. Training-based discrete in-service workshops may be useful for delivering certain types of information such as methods for organizing portfolio assessment of students' work (Little, 1993) or teaching specific skills such as the use of a particular computer software package (Grant, 1997). However, their usefulness as the dominant channel of professional development in diverse contexts has been widely criticized.

The recent criticism of the "training" paradigm and the form of professional development associated with it (Darling-Hammond & McLaughlin, 1995), advances in research on adult learning (Wood & Thompson, 1980) and the change process (Fullan, 1993), and identification of new needs for science education reform have led to new views about professional development and its role in improving education. New guidelines have emerged for the professional development of science teachers in order to facilitate the desired reform. These are best illustrated by the Standards for Professional Development for Teachers of Science, which are guided by a spirit of "change throughout the system" (National Research Council, 1996, p. 72). Accordingly, the standards encompass shift in several areas of emphases in the professional development of science teachers, which reflect the changing conception of the role of professional development in educational reform as well as the role of teachers in the professional development and reform process.

Moving from In-service Education to Professional Development: An STS Based Approach

School education in the sciences must change to reflect the changing nature of science as well as the changing notions of desirable science education. Two developments-the changing notion of in-service education and the changing notion of the desirable science education-have led to an urgent need for effective professional development programs that address both of these developments. However, one does not find an abundance of such programs with proven track records.

Using an STS approach (NSTA, 1990-91, pp.47-48) to both science instruction and professional development of science teachers, the Iowa Chautauqua Program (ICP), developed at the University of Iowa (Iowa City, Iowa, USA) during the early 1980s, emerged as an exemplary model of professional development for K-12 in-service science teachers. It was recognized and validated by the U. S. Department of Education as a model professional development program worthy of dissemination and emulation. Consequently, the ICP model has been emulated in several states in the USA and in several countries worldwide during the last decade (Dass & Yager, 1999). The key elements of the program, which make ICP an exemplary model of professional development reform, include learning experiences based on research compatible ideas actively involving teachers, expectation from teachers to practice what they learn, feedback and follow-up support, and an on-going approach involving collaborative efforts. Central to these key elements is the STS instructional approach-using real-life situations, questions, concerns, and problems as the context and starting points for studying science.

The ICP model is based upon the idea that "in-service education is both a strategy for specific instructional change as well as a strategy for basic organizational change in the way teachers work and learn together" (Blunck, 1993, p. 132). This basis of the ICP model is congruent with the current notion of professional development for continuous enhancement and ongoing learning of teachers. The STS approach is poised to provide real-life relevance to school science education. Thus, an engagement with the STS approach through the ICP model addresses both of the developments mentioned above. Further, ICP model and the STS approach embedded within it have a track record that proves their effectiveness in bringing about the desired reform both in general professional growth of teachers and in specific science instruction in their classes (Blunck & Yager, 1996). The fact that this 'package' (STS and ICP) of professional development model has been emulated successfully in several different settings worldwide attests to its adaptability to local educational realities and priorities. Thus, the STS approach presented through the ICP model of professional development offers undeniable promise of contributing to educational reform much desired around the world during the present century.

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Health Education in Timor Leste (East Timor): A Case Study

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The conclusion of the electoral process in April 2002, paved the way for the declaration of independence on 20 May 2002, making Timor Leste (East Timor) the world's newest democracy. The purpose of this study is to describe and analyse the status of health education in the world's newest democracy. The specific aims of this longitudinal study being carried out over 3 years were: to obtain a broad overview of the current health education curriculum in East Timor, to identify the professional development needs of teachers teaching health education at the primary and lower secondary level and to develop an health education module in Portuguese and Tetum for primary schools to be trialled in two schools in Baucau, East Timor.

The research used an interpretive case study approach in which multiple methods, sensitive to the context, included in-depth and focus group interviews, school visits, accumulation of documentary data and reflective narratives. This paper documents the challenges faced by teachers in the implementation of a relevant health education in a post-conflict transitional society.

Background to the Study

East Timor: A background to the world's newest nation

The Democratic Republic of Timor Leste (East Timor) is in many regards a 'new' nation. From 1975 until an independence referendum in August, 1999, the nation was 'annexed' by the Republic of Indonesia. It is widely recognised that these decades were marked by violence, human rights abuses and an estimated 200,000 deaths throughout a long-term guerilla resistance (Dunn, 2003; WHO, 2000a). For the more than 450 years prior to Indonesian involvement, Timor Leste (East Timor) was a colony of Portugal (Dunn, 2003).

Immediately following the referendum vote, anti-independence groups led a violent assault on the nation's people and infrastructure, in which many East Timorese were killed, injured and the infrastructure destroyed (Adhikary, 2002). Up to three-quarters of the estimated population of 850,000 was displaced and health facilities were damaged or destroyed (Dunn, 2003; WHO, 2000). In addition, the emigration of core Indonesian health professionals caused the "total collapse" of the health system (WHO, 2000, p.1).

Health Indicators in East Timor

Although currently 80% of the population has access to health services of some description (with an average walking time of 70 minutes) (WHO, 2003), there is an acute lack of trained health workers, and doctors. Continuing problems include:

- A strong potential for epidemics of malaria, dengue haemorrhagic fever, Japanese encephalitis, cholera, typhoid, tuberculosis and diarrhea (WHO, 2003).
- Maternal, infant and under-five mortality rates are at unacceptably high levels (WHO, 2003).
- Around half of all women and young children have anaemia and around half of all children under 5 are under-weight (WHO, 2003).
- Water supplies and sanitation reportedly remain very poor, with inadequate or non-existent systems for the formal collection of garbage and hazardous medical waste (Adhikary, 2002).
- 41% of the population lives below the national poverty line of 55 US cents per day (UNDP-HDR, 2002).

Theoretical Underpinings

Focusing Resources on Effective School Health (The FRESH approach)

Good health and nutrition are both essential inputs and important outcomes of basic education. First, children must be healthy and well-nourished in order to fully participate in education and gain its maximum benefits. In addition, a healthy, safe and secure school environment can help protect children from health hazards, abuse and exclusion (WHO, 1996; UNESCO, 2002)

International agencies such as WHO, UNICEF, UNESCO and the World Bank believe that there is a core group of cost effective strategies for making schools healthy for children and so contribute to the development of child-friendly schools. These agencies have launched a new approach to health education called FRESH (Focusing Resources on Effective School Health). Through this approach health policies are adopted and implemented in schools that address the provision of safe water and sanitation, a skills-based health education and school based nutrition and health services

(UNESCO, 2002).

School Health Education

The arguments for using schools for the dissemination of health education and treatment are logical: there are invariably more schools than clinics in developing countries, and as schools effectively gather children together in one place, they provide an ideal environment for targeted health education. There are numerous reports of the effective use of school-based health programmes to diagnose and/or treat conditions such as malaria and schistosomiasis (Hall, Adjei & Kihamia 1996). Furthermore, children are accustomed to receiving instruction in classroom situations, and they are thus more receptive and responsive to specific health education messages, and more inclined to assimilate the information and relay it to other household members.

The Child-to-Child Concept

According to research conducted by Rohde and Sadjimin (1980), information conveyed by school children to other household members is generally perceived to be modern, reliable, and believable. This concept was also effectively used by schools in Uganda (Ministry of Education, Uganda, 1992). Indeed, school health programmes are so efficacious in influencing community perceptions and behaviours that they have been specifically identified by the World Bank (1993) as one of the six most cost effective public health strategies in use.

Research plan, Methods and Techniques

Using Multiple Research Methods

In the context of Timor Leste (East Timor), the study was an enquiry into a complex transitional society. The case study used a multi-method approach using qualitative data with interpretative and critical ethnographic analysis to allow triangulation of methods and cross validation of the data (Denzin & Lincoln, 2000).

Sample

Qualitative data was collected from teachers, head teachers, education personnel and lower secondary students from schools in Dili and Baucau. 4 classroom health science lessons with 2 each in primary and secondary schools were observed. Focus group discussions on health issues were conducted with teachers and students. Documents on teaching health issues in schools were obtained from the Ministry of Education.

The first phase of the study, involved in-depth focus group discussions with primary teachers and lower secondary science teachers and secondary school students and addressed health related teaching and learning issues. This phase provided a broad overview of the health education taught in schools.

In the second phase, 4 health science lessons in primary and secondary schools were observed using a semi-structured class observation schedule, for the purpose of identifying classroom practices and professional development needs in East Timor.

In the final phase, teachers were introduced to primary health education modules. Teachers then identified those modules relevant to their context. The modules were then translated into Portuguese and Tetum. A manual was developed based on these modules and is currently being trialled in 2 schools in Baucau, Timor Leste.

Discussion and Conclusion

Like the WHO, 1996 report on improving school health programs, this research also identified the challenges facing a post-conflict transitional society as an acute lack of infrastructure and resources, lack of trained teachers to teach health education, an impoverished population that struggles to survive, a shortage of funds to train teachers and buy resources. But meeting and talking to the teachers and students has given the researcher another lesson in resilience, endurance and hope: that teachers in the transitional nation of Timor Leste want to succeed against all odds.

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Common Knowledge Construction Model for Teaching and Learning Science: Applications in the Indian Context

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Objectives

Teacher centered pedagogical practices, which focus on acquisition of facts, still dominate the Indian Science classrooms. Transmission of facts result in clutter of 'inert ideas,' which the students are not able to use effectively in familiar contexts and creatively in open-ended problem - solving situations (Rao, 2003). A teaching model that promotes new directions in science teaching and considers students' personal meaning in lesson sequences is referred to as the *Common Knowledge Construction Model* (CKCM) (Ebenezer & Haggarty, 1999). This teaching model advocates scientific reasoning through conceptual change inquiry using students' multiple meanings of natural and social phenomena. The objective of this poster presentation is to report two aspects of our major, on-going complex study based on the implementation of the CKCM in the Indian context. Correspondingly, we answer two research questions based on the first phase of the model, Exploring and Categorizing students' ideas.

1. What are grade 7 students' conceptions of excretion?

2. What are the classroom teacher's perceptions when the researcher modeled the CKCM in a unit on excretion?

Significance of the Study

This study helps teachers to understand how they can meaningfully connect students' prior ideas to the curriculum. It orients the science teacher of the importance of common knowledge, which can be a base line from which he/she can spiral the scientific ideas of the students to higher level of reasoning. The teacher becomes conscious of how children's ideas develop and conceptual change occurs in the progression of a unit of study.

Underlying Theoretical Framework

CKCM is a philosophically sound teaching model that is premised on Marton's "relational learning" (Marton, 1981), Bruner's view of language as culture's symbolic system (Bruner, 1986), Vygotsky's zone of proximal development (Vygotsky, 1968, 1978), and Doll's post modern thinking on scientific discourse and curriculum development (Doll, 1993). This model acknowledges that children hold beliefs about the world that they have constructed through personal interaction with natural phenomena and through social interaction with other people (Ebenezer & Haggerty 1999)

Research Design & Procedure

To answer the first question, we explored 7th standard students' ideas of excretion by having them answer the following question in writing using paper and pencil/pen.

Draw and write how waste products are produced and removed.

We collected their "ideas sheets" and categorized their ideas into "phenomenographic categories" following the research tradition of Marton (1981).

To answer the second research question, an interview was conducted with the classroom teacher who observed Sheela Chacko teaching a unit on excretion of animals from the CKCM perspectives.

Findings

The phenomenographic categories are presented in Table 1.

This study shows that children have prior idea on excretion, which can be used as a basis for developing a sequence of lessons. The researcher, in fact, upon the invitation of the regular 7th standard teacher, developed lesson sequences based on the ideas represented in Table 1, and taught the class a unit on the excretion of animals for a period of 2 weeks. Several teachers were curious and observed Sheela's newly developed teaching ideas.

This study has generated students' ideas for curriculum development. The classroom and excerpts from

Table 1. Seventh standard students' conceptions of how waste products are produced

Students' Conceptions	Students' Expressions	Frequency (n=31)
Digestion of food (n=18) By eating food	"They are produced by when we eat it, is going to be digested so this is the way waste is produced" "We eat our food and it goes to the small intestine and digest and it is produced" "They are produced when the food is digested… when we eat the food the food goes to the stomach it is digested and it is pushed out. "	9
Food that is/not digested	"By the food which is not digested"	2
More food than the body requires	"They are produced when we eat more food that is not required for our body the left over food becomes waste"	2
In-take of needed food and excretion of the left over food	"They are produced when we eat food it get s digested and all we need for our energy, like protein calcium etc and the left over is waste"	3
When we eat the food the good products are taken and bad are excreted (1)	"They are produced when we eat the food the good products are taken and bad are excreted…first we eat the food it goes in the stomach and into the small intestine which takes the good products and the large intestine which take the bad products are excreted."	1
The intake of vitamins	"They are produced after we eat the food the digestion takes place the vitamins will go into the body and then when waste food are left it will be sent out."	1
Kidneys produce waste products	"With the help of our kidneys" "Kidneys help."	4
Digestion of food and urinary ducts	"They are produced because of digestion takes place in our body and produced in urinary ducts"	1
Miscellaneous	"When we eat food or water the stomach is full and it produce gases and we go toilet" "They are produced by excreting our" "They are produced by bacterial" "By eating, the waste products will come out. by eating they are produced" "They are produced from smallest particle from the body" "It goes in and then it mixes and it is removed." "They are not needed so they are product" "Some harmful effect" "The waste products is done something and excreted"	9

an interview with regular teacher revealed the following insights about the CKCM model: requires much preparation, needs to reduce class load; highly interactive; student understanding is better; the size of class needs to be considerably reduced; learning is fun; and eagerness to learn. Because this is the first time the teacher attempted to implement the CKCM, she was able to see first hand, how it played out in the classroom. Both the researcher and teacher developed understandings of how students generated their own ideas based on the meaningful experiences given in the classroom. This classroom-based research context gave the participants to generate useful knowledge for themselves. And because of this experience they will be able to teach inquiry-based conceptual change models such as the CKCM in school science. Because of the learning experience in this classroom-based experience, the researcher and the teacher will develop the capacity and confidence to implement lesson sequences that aim to explore, assess, develop, and monitor children's ideas of science concepts as well as develop children's knowledge, understandings, and skills in "doing," "writing," and "talking" science, using relevant curricular materials, resources, and technologies.

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Understanding Science Teaching and Conceptions of the Nature of Science in Pakistan through a Life History Study

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In this study I have tried to understand and develop a deeper understanding of science teaching in Pakistan. Two main questions guided the inquiry:

1) What is a female science teacher's understanding of teaching science in a school in Pakistan?

2) What aspects of the science teacher's conceptions of the nature of science are explicit in her practice?

I have used a narrative mode of research, using what is called the life history method. Life histories allow and encourage the researcher to adopt a broader understanding of teaching by providing illustration of the relationships between various aspects of teachers' lives and their teaching practice, both inside and beyond the classroom. I chose to work with a female teacher because I myself have been a female teacher of science. My own experience of school and teaching gave the science teacher and me a shared basis for understanding each other. Another reason that I chose to work with a female teacher is that Pakistan is a highly patriarchal society and I was concerned that the power imbalance between the sexes might affect the data generated.

I interviewed Munazza[1] thirteen times and engaged in innumerable conversations with her while observing her teach science in classes seven and eight spread over a time period of 15 months. Munazza is a young science teacher with a BSc degree and eight years experience of teaching. She has had no exposure to teacher education, as teacher training is not deemed essential, especially for teachers in the private sector. She taught in an urban coeducational, afternoon shift school of a

[1] Pseudonyms have been used for the teacher and the school in which she practiced

large private school system in Karachi. I have named this school the Karachi Model Secondary School (KMSS)[1]. I also observed a few of Munazza's other classes and interviewed a number of science teachers in the school and members of the administrative staff. The purpose was to obtain a complete picture of her teaching practice within the school context.

The importance of this study does not lie in the construction of universal truths about knowledge that science teachers have about teaching. Its significance lies in the deeper understanding of a teacher's practical knowledge of teaching and a more penetrating view of her epistemological understanding of school science. The rich description of her personal life and her classroom teaching, supported by analytic interpretations of her classroom teaching and her conceptions of the nature of science, shows the deep parallels between her personal life and professional life. It also lays bares the complexity of teaching that belies efforts to render it technical and mechanistic by some forms of curriculum reform.

Analysis of data took place at several levels. The first level was the informal analysis and interpretation that took place while interviewing and observing. The second level of analysis was the reading and writing of interview summaries and field notes. This also included sharing the summaries with Munazza. The third level was the beginning of more formal data analysis where I read through the data to select stories for portrayal. The fourth level involved the use of different techniques to analyze data. I used an eclectic mix of techniques to analyze data, drawing on work by Strauss & Corbin (1990) and Lofland & Lofland (1995).

Munazza has a good grounding of science content knowledge and that helps her to devise activities for student learning. However, her repertoire of ways to deal with students and teaching science depends on how she experienced teaching in school and college. Though she wants to and has tried to teach in the way that she was *not* taught but without experience of what that means she remains limited in her efforts. If teachers are to act as pedagogical change-agents, then new ways of thinking about teaching and knowledge have to become a part of their experiences - a part of their lives. This study has made it clear that teachers are much more likely to use methods of teaching or ways of thinking that they were exposed to when in school or college.

Science teaching is a difficult job. Teachers have to do a number of things in class - teach scientific content, develop the skills of science and foster scientific attitudes. As if this was not enough, science teachers also need to pay attention to the messages they convey explicitly or implicitly about the nature of science. Analysis of data showed that Munazza has strongly positivist conceptions about the nature of science. She believes that all scientific propositions are based on data and that observations of reality correspond exactly to an external reality. Her conceptions include the belief that reality is directly accessible through the senses. An apriori theoretical lens is not needed to direct observation and to make sense of data. She also believes that science is value-free, superior and a stable form of knowing. She believes that science is a masculine domain and is a hard subject where women have to work harder to make a place for themselves. These views are conveyed to her through teaching of science in school and college, through her textbooks and even the society at large. An illusion of science knowledge as complete and certain governs her pedagogy in science teaching.

Conclusions of this study emphasize that early experiences influence beliefs and behaviours regarding teaching and learning. Enabling teachers to identify these life experiences provide them with insight into their philosophical position about education, about the nature of science and pedagogical decisions taken in the classroom. Opportunity for teacher educators to engage in this kind of reflection with teachers has some distinct benefits. It has the potential of making explicit the difference between teachers' 'theory-in-use' and 'espoused theory' (Argyris and Schon, 1980). Through this confrontation teachers can become more aware of their theory-in-use and learn to act more effectively in and outside the classroom. My study has shown that teachers will use their personal practical knowledge to make decisions about what and how to teach in the class and that the basis for this kind of knowledge is their life history. This is the only kind of professional development that lasts – to make innovation a part of the life experience and life history of the teacher.

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Trends and Issues of Research on In-Service Needs Assessment of Science Teachers: Global Vs the Malaysian Context

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Introduction

In this ever changing globalized world, the discipline of science (Biology, Physics and Chemistry) is continuously evolving. Similarly, instructional techniques used to teach the knowledge are also developed at the same pace, both as a result of new developments in Information and Communication Technology (ICT) and research in science teaching and learning. Consequently, practicing science teachers need to update their knowledge in both content and pedagogy. It is a well-known phenomenon that, in most countries, teachers of various subject knowledge expertise are often made to teach science subjects that they are not trained for. The need to continuously develop professionally is critical for science teachers. Even though these teachers might have used various kinds of coping strategies and safety net in their teaching, they still need in-service training courses to teach science meaningfully and effectively.

Objectives of the study

The main objective of the study is to identify the most prevalent needs as perceived by the Malaysian secondary science teachers in keeping abreast with the current demand in science teaching and learning and in meeting the challenges of globalization. More specifically, the objective is to identify the most prevalent needs for in service training as perceived by secondary science teachers in terms of a) science content mastery, b) pedagogical skills, c) knowledge skills in classroom and laboratory management, d) the application and integration of computers in science teaching and e) the usage of English in Mathematics and Science teaching.

This needs assessment study is essential for two purposes. First, in the Malaysian context, the last comprehensive study on the needs of in service training of science teachers was conducted in 1983. Therefore, as mentioned above, there is a need to revisit the needs of secondary Malaysian science teachers. Second, for an effective in-service training program, the program development should be directed towards meeting the stated needs of the teachers' concerns (Amir, 1993). Thus, assessing the learner needs in the planning process is an important step.

Pertinent literature review of in service needs of science teachers.

The needs assessment defined in this study is specific to science teachers' needs, in that we adopted Moore's (1977:145) definition, which is "… a conscious drive, or desire on the part of the science teacher which is necessary for the improvement of science teaching." For the purpose and context of this needs assessment study, *System Model* put forward by Kaufman (1972), which is widely used by needs assessors, is adopted. The model identifies primary needs, summarizes the nature of primary needs, and prioritizes needs for action planning.

In terms of empirical studies on in-service needs of science teachers, there appears to be a significant difference between the needs of science teachers from developed countries (such as the United States) compared to the needs of those from developing countries such as Malaysia and Jordan. It has been shown that the needs of science teachers from the developed countries (Baird and Rowsey, 1989; Mann 1993; State of Delware; 2002) focused more on the development of students such as 'to motivate students', 'to develop strategies on developing conceptual understanding' and 'to develop strategies to promote analytical thinking and problem-solving skills'. On the other hand, the prominent needs perceived by Malaysian and Jordanian science teachers (Bakar, Rubba, Tomera & Zurub, 1988; Abu Bakar and Tarmizi 1995 and Idris 2001) were focused more on self-improvement such as 'being creative in science instruction' and 'updating knowledge of science innovations in science instruction'.

Methodology

The Science Teacher Inventory Needs of Science (STIN-Zurub & Rubba, 1983) instrument was modified and administered to 1650 science secondary teachers. A total of 72 items was constructed to reflect the needs of science teachers in secondary schools in Malaysia. First, existing perceive needs subscale were reviewed followed by a thorough review and analysis of the needs literature. Then a panel of experts in the area of science teaching representing Biology, Chemistry and Physics was asked to edit, combine, suggest and eliminate items from the initial pool of items. Through factor analysis, 8 factors and were identified. The categories were: 1) Managing and Administering Science Instruction, 2) Diagnosing and Evaluating Learners for Science Instruction, 3) Science Teacher Self Improvement, 4) Subject matter knowledge, 5) Administering laboratory science apparatus, 6) Planning science instruction, 7) The use of ICT in Science Instruction and 8) The Use of English in Science Teaching.

Findings

Data analysis indicated that the top 10 perceived needs were mainly related to the following three categories 1) The Use of ICT In Science Instruction, 2) Science Teacher Self Improvement and 3) The Use Of English In Teaching Science. The first and third findings are obviously contextual in nature whereby these particular needs arise due to the recent Malaysian government policy on the teaching of Science and Mathematics. The policy requires science and mathematics to be taught in English. 85 per cent of the respondents state the need to increase their proficiency in English. The policy also emphasizes the use of ICT in science teaching. Again, about 95 per cent of the respondents indicated the need to increase their knowledge related to ICT in order to teach science effectively.

It appears that the orientation of the needs was to develop teachers' own competency, both in English and ICT, as a response to the current development. However, such needs could be seen as a conscious drive on the part of the teachers to improve science teaching through improving oneself first. This hypothesis is further supported by another prominent needs indicated by the science teachers, which are related to the need for self-improvement. The needs revolve around concerns such as 'to improve professionalism through inservice courses', 'to gain knowledge on innovative science teaching' and 'to enhance one's thinking skills'. It appears that over the years, Malaysian science teachers needs seem to still focus on the improvement of oneself. Perhaps, the traditional notion of teaching and learning, where teachers are source of knowledge, and are still the main practice in Malaysia, determines the needs of the teachers.

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The Concept of Force

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The concept of Force is the most fundamental yet the most misunderstood concept in physics especially by the students up to higher secondary level. Learning materials in print form, which discuss the *formation* of these concepts, technically known as *cognition* or in Piagetian terminology, *schemata*, are rarely available to a practicing teacher or to learners. Here we present what special and technical meaning the concept of force has in the realm of pre-relativistic classical physics and review the existence of various alternative conceptions of the learners reported in some research studies. In particular we have presented the studies on school and college students spanning from the period 1983 to 1998. From these studies following alternative conceptions are culled out for the purpose of discussion in this presentation.

1. Force is associated with the body till it is in mo tion.

2. When a body is at rest the force acting on it is zero.

3. Force is always in the same direction as the velocity of the body.

4. If the velocity is changing then the force is also changing.

5. Centripetal force and centrifugal force both act on the body moving uniformly in a circle.

6. The action-reaction forces act on the same body.

7. The product of mass and acceleration is a force.

8. Only animate things like people and animals exert forces; passive ones like tables, floors do not exert forces.

9. A force applied by, say a hand, still acts on the object even after the object leaves the hand.

We present Osborne's (1985) thought experiment as a teaching episode to find out alternative conceptions of students at higher secondary level regarding the concept of force. The episode in brief is as follows.:

Consider an elastic ball. If we just drop the ball, it will go down. On its journey downward if it meets a perfectly elastic horizontal floor, it will return to the same spot from where we dropped it. This process would continue for ever. State the direction of the force acting on the ball when it passes through a midway point B as it travels

i) upwards

ii) downwards

This episode is used to create the cognitive conflict in terms of opposite responses regarding the direction of force acting on the ball during its to and fro journey. The students are also asked to justify each of their responses.

This gives a large repertoire of alternative conceptions about force. It is stated that the correct response can be arrived at by two different routes. One shorter and the other longer one. The shorter route asks the student just a simple question what applies the force. Because the earth applies the force so it is always downwards hence the force is always downwards. The longer route is to find the direction of the acceleration or change of momentum. This is also always downwards.

The other alternative conceptions about force are then taken one by one. Possible causes for formation of the alternative conceptions are discussed at length. These are as follows.

a) The familiarity with the use of the term force in our everyday language creates some alternative conceptions. For example we say:

1. Water is coming out of the tap with great force.

2. Force within the earth pulls the stone down.

3. The police forced the door open

4. In spite of applying so much force the lid of the tin is not opening

5. The earth keeps us tied down to itself by gravitational force.

b) The other reason for alternative conceptions about force is the Aristotelian idea about the state of rest being the preferred state.

c) Lastly it is our faulty way of teaching the concept of force from primary to secondary level, which gives rise to alternative conceptions. The alternative conceptions about force are also related with the alternative concepts about velocity and acceleration.

Some exemplar teaching and testing strategies are also illustrated in this presentation. For example, it is stated that "force" is an abstract concept and that there does not exist a definition of force independent of Newton's laws of motion. In particular the first law gives a criterion to find out whether an unbalanced force acts on the body or not. The second law, while giving us the unit of force also gives the quantitative measure of the unbalanced force. But still they both do not tell us anything about the physical cause of the force. The third law tells us that the force is a result of interaction. All the three laws define the concept of force. Many alternative conceptions particularly about third law of motion widely held by public in general are also commented upon. Identification of correct pair of action reaction forces is also explained carefully. The concept of centrifugal force is explained as pseudo force to make the Newton's laws valid even in non-inertial frame of reference. Any given problem can be analyzed both in an inertial and non-inertial frame. A modified definition of weight is suggested to explain the weight measured in an accelerated frame. Operationally, weight of a body is what the balance measures. It turns out that, weight should be defined as the opposite of the reaction that the floor or support applies on the body. In this connection it is stated that the concept of friction, tension, reaction and pressure are self-adjusting forces.

Sufficient number of problems, simple but illustrating the various aspects of the concept of force are also listed. Concept of force is used as an illustration to train the learners to talk and think aloud about force and other related concepts and events. Detailed mathematical analysis has been deliberately left out which can be easily found in any textbook. The presentation is expected to encourage the learners to think about and sometimes question the way we think and interpret events without being judgmental about ourselves. Lastly the two important aspects of scientific method, the logical thinking and curiosity to experiment are also illustrated taking concept of force as one example.

The teachers as well as self-learners can profitably use this in their attempts to develop correct concept about force.

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Problems and Possibilities of "General Science Education" for College Students

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1

As modern science was accepted by the universities, the sciences of the universities become gradually specialized. By the late nineteenth century, the basic structure of the university science, composed of the specialized disciplines as we see today, was established. Afterwards, the science in the universities kept increasing the degree of specialization while maintaining the skeleton of the same structure.

Such specialization initially contributed to the growth and development of sciences, and helped to create a social role of science that included the application of science to industry. And this led the universities and society to support science. Yet, while the science in the universities was following this path of ever increasing specialization after the mid-nineteenth century, the way science was practiced, and the place and role of science in society continued to change. There appeared many problems which had not existed a century ago, and the specialized sciences of the universities became less and less capable of dealing with these problems.

To be sure, a great deal of these problems are the problems for the scientists themselves. But the changes mentioned above created problems for the general population also. Even the task of "managing" the big, expensive, industrialized science is not the work of scientists alone. Moreover, everyone living in the modern world has to face those problems that are becoming increasingly more serious for the entire population, which are either created by science or at least related with it. Indeed, science has come to be connected with most problems of modern society.

Meanwhile, the science of the university has become ever more specialized in its content. This has made the university science, which had already been separated from the general public because of the difficulty of its specialized content, even more alienated from them. The specialization has gone too far for the university science to be able to deal properly with the needs and problems of the society; it has even become indifferent to them. This kind of situation can easily lead to an atmosphere of "anti-science"; it even contains a danger of making science a factor of social conflict.

The task of educating the general public properly so that they can live in a society in which the above kind of problems are becoming increasingly more important falls on the education of science as "liberal arts"—the "general science education".

2

In most Korean universities the targets of the general science education are the students who do not major in sciences or related areas (hereafter, "non-science students"). A common characteristic of these students is that they are generally ignorant of the sciences, and often have prejudices against them. Yet, when they graduate and enter society, they face, and are forced to deal with, the above kind of problems. The result, then, will be a society in the future, in which these non-science students, ignorant of, and prejudiced against, science, have to play leading roles in the science and technology policy and administration, dealing with numerous science-related problems and making decisions on them.

This is an ominous situation. The need for a proper "general science education" for them, which will provide them with a correct understanding of science, and prepare them to deal with many science-related problems, is obvious. It is important for the future of the society. Moreover, it should be noted that general science education in the universities will be the last chance for the non-science students to learn about science, and thus, general science education for non-science students can be considered even more important than science education for the students majoring in the sciences.

3

It is not possible to teach, in general science education, the technical content of all sciences. On the other hand, however, general science education cannot do away with scientific content entirely. It becomes thus necessary to make selections from various contents of all the sciences. One thing is clear however, that such selections should be made for students, and not for teachers.

What are usually mentioned as goals of science education—1) acquisition of scientific knowledge, and 2) fostering scientific attitude and mentality—cannot be the aims of general science education. These two aims should of course be essential ingredients of general science education. But they are aims that should be pursued in secondary schools, and are neither appropriate nor possible for university-level general science education.

Those non-science students who take general science courses will live in society not as producers of scientific knowledge, but as its consumers, users, and managers. Thus, the problems awaiting them are not what can be solved by specialized scientific knowledge. To deal with them, it is far more necessary to understand the nature of scientific knowledge, the characteristics of scientific activity, and the relation between science and various elements of society, than to learn the detailed contents of sciences. And in the course of dealing with these problems, the general science courses should teach students to see science not just as a finished form of organized systematic knowledge, but also as an important cultural and social phenomenon in modern society. That will be the true goal of the general science education in modern society.

4

It will be necessary for a university to select courses appropriate for the university and its students. It is important, however, to make a broad range of courses available to the students so that they can make a balanced selection from them. A considerable freedom should be given to students to make such selections. Also, the general science courses should be taught by specialists, who possess not only sufficient knowledge of scientific content but understanding of the science-related problems discussed above.

5

General science education should also be provided to the students majoring in sciences. First, they also face and deal with the above-mentioned science-related problems in society in which they live as citizens. Often, they are expected to help the general public to make choices or decisions about these problems. Moreover, many problems these students will face in the future working as scientists are not problems of scientific content. General science education in the universities will provide the students majoring in sciences with understanding that will be helpful for them to deal with these problems.

Putting Imagery Back into Learning: The Case of Drawings in Human Physiology

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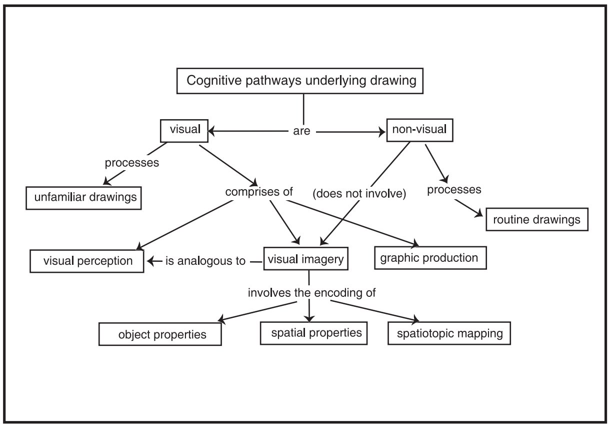
Visual imagery is widely recognised as an important mode of cognition. Kosslyn and others (e.g. Kosslyn and Koenig, 1992) have shown a close relationship between visual imagery and visual perception, which leads to our ability to manipulate and interpret mental images in new ways. Working with images is greatly facilitated by the human ability to draw using an external medium.

Children's drawing has been seen as an indicator of development (e.g. Piaget and Inhelder, 1967). Karmiloff-Smith (1995) in re-looking at cognitive development, argued for system-specific constraints in the notational domain (in which she included both drawing and writing). Drawings have been viewed as a medium for social and cultural transaction (research inspired by Vygotsky: Brooks, 2002), learning and thinking (Arnheim, 1974) and as a tool for problem-solving (Ramadas and Shayer, 1993). The relationship between drawings and visual imagery has however been little explored. In general, research on drawings has focused on early spontaneous productions while that on imagery has dealt with simple, easily coded depictions.

The practice as well as pedagogy of the image-rich field of science depends critically on the use of drawings. Drawings in science are embedded within an elaborate conceptual context. Children's use of drawings in science therefore, must be seen in relation to their visual imagery as well as to their propositional understanding in the content area. Here we employ Paivio's dual-coding hypothesis relating to two separate but highly interconnected components or coding systems of cognition, namely, imaginal and verbal. While the verbal system processes linguistic materials, the non-verbal system (a major aspect of which is visual imagery) is specialised for the processing of non-verbal data (Paivio, 1980).

To understand the role of imagery in drawing, we used the model of van Sommers as modified by Guérin et al. (1999). The model posits two kinds of cognitive pathways in the production of drawings: a visual pathway for the processing of novel and unfamiliar drawings, and a non-visual pathway for the processing of routine, familiar drawings. We submit that the current pedagogy of science bypasses the visual imagery pathway, leading to routine processing of drawing. Some evidence is discussed and remedies suggested.

Fig. 1 *A schematic representation of the model of Guérin et al. (1999)*



Methodology

Twelve mixed-ability students from classes 6, 7 and 8 of an English medium school in Mumbai, India were asked to respond to four questionnaires pertaining to the structure and functioning of the human body, specifically the systems: digestive, respiratory, circulatory, nervous and excretory. The questions conformed to the content of the textbooks used in their school. Students were provided with outlines of the human body, within which they could draw the systems. The questionnaire required the students to perform three tasks:

- Draw the organs of a particular system of the body using plain lead pencils along with colour pencils or crayons.
- Visualise the process of digestion, respiration, circulation, etc. by forming a visual mental image of it, for example, of eating a favourite food, tracing the path of a drop of blood through the body, tracing the path of a nerve impulse on touching a hot object, etc. They were asked to depict these processes through drawings and words. This question probed their understanding of function and their spontaneous use of drawings.
- Describe the images they visualized when thinking about a given structure or process. Analogy was used as a tool to enable the subjects to generate visual images.

The questionnaire was followed by clinical interviews. The subjects were asked about their preferred mode of communication- either drawings or written expression. They were also asked if drawings could replace written content in textbooks.

Analysis

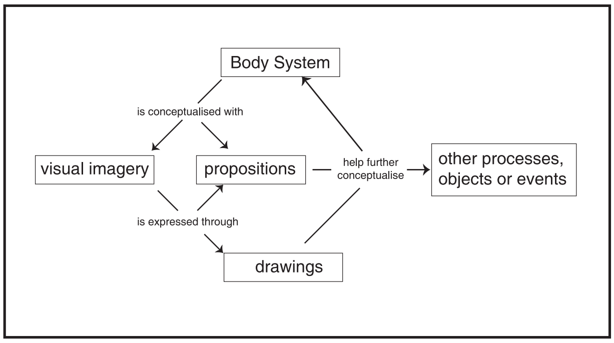
The analysis included:

- A classification of the generated visual images.
- A classification of drawings depicting body systems.
- Case studies of a few students to illustrate usage of visual imagery and pictorial notation.

Findings and conclusions

Students' drawings largely conformed to those in their textbooks. Questions about processes however, spontaneously, elicited flow-charts, a list of organs or a list of concepts connected by arrows. We argue that their drawings and descriptions, both written and spoken, suggest the use of a primarily non-visual pathway. Ideally, if the visual imagery pathway could be activated, it would enable drawings to be used as a tool for thought as shown in Fig. 2.

Fig. 2 *Role of imagery and drawing in the conceptualisation of any specific content area*



Subjects were equally divided in their stated preference for diagrammatic or written expression. However, their written responses indicate that they were more at ease with propositional descriptions and less comfortable with using drawings. Some common alternative conceptions about the working of the human body were also identified

Forming a visual image and manipulating its components enhances learning and problem-solving. In this study, we used analogical thinking as a data gathering tool, but found that it served a pedagogical function also, by facilitating visualisation. We propose that in the case of human physiology, visual imagery is a mediator for drawings to function as a tool for thinking and learning.

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Anchoring Science Education Towards Scientifically Literate Malaysian Society: An Exploration of Children's Affective Psyche

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Objectives and Significance of Study

This paper takes as it starting point the document Vision 2020, inspired by the former Prime Minister of Malaysia, and examines the way in which the science curriculum might make a material contribution to the future Malaysian society. In particular, it argues that the science curriculum is in a unique position to take up the challenge of *"establishing a scientific and literate society, a society that is innovative and forward-looking, one that is not only a consumer of technology, but also a contributor of the scientific and technological civilization of the future."* Such characteristics of Malaysian society must be produced by its education system, particularly science education so that Malaysians are capable of competing in all aspects of human civilization, not only at national level, but also in an international setting. In an effort to establish such scientific and literate society, this paper argues that children's scientific attitudes as well as their attitudes towards science must be nurtured. By possessing positive scientific attitudes and attitudes towards science, it is argued that children will have strong inclination towards science and hence have strong tendency to embark themselves in science related careers.

Underlying Theoretical Framework

In the field of attitude research, there is a significant debate between two schools of thought regarding the meaning of attitude itself. Attitude, as conceptualised by Krech, Crutchfield and Ballackey (1962) embrace three distinct components: the *affective*, the *behavioural (conative),* and the *cognitive*. More recently, another school of thought, represented by Fishbein and Ajzen (1975) contend that attitude measurement should be concerned solely with the *affective* domain, and that the *behavioural* (*conative*) and *cognitive* components should be assessed separately. Nevertheless, as pointed by Koballa (1989), regardless of whether it is the age-old trilogy or monology of attitude one has accepted, what is important is that attitudes are learned either actively or vicariously, and therefore, can be taught.

Essentially, attitudes towards science involve feelings, opinions, beliefs, and appreciation, which individuals have formed as a result of interacting directly or indirectly with the various aspects of the scientific enterprise (Hasan & Bileh, 1975, Munby, 1983). It also covers emotional reactions someone exhibits towards science (Gardner, 1975). The term "scientific attitudes" on the other hand is perceived as desirable attributes of scientists in professional work and could be categorized as interests, adjustments, appreciation as well as values. These attributes include open-mindedness, critical mindedness, suspended judgment, curiosity, intellectual honesty, skepticism, rationality, objectivity, and questioning attitudes (Kozlow and Nay, 1974; Krynoiwsky, 1985). Gauld refers to scientific attitudes as the execution of that particular approach to solving problems, assessing ideas and information and making decisions. Cognizing the wide array of definitions of scientific attitudes, this paper offers a different insight to these definitions of scientific attitudes; viz. it refers to attributes needed in executing higher order thinking, especially solving problems, judging ideas and making decisions. It could therefore be argued that having such attributes could ensure someone not merely being able to interpret the scientific knowledge and method as well as other things concerning their daily lives experiences.

In this paper, the prime aims are twofold: the first segment will focus on the concept of attitude towards science and scientific attitudes. In this section, extensive literature review on those concepts will be conducted, which ultimately bring about authors' unique conceptions of attitude towards science and scientific attitudes. In line with the definition, relationship between scientific attitudes and critical thinking dispositions – dispositions needed to inspire someone to think critically will also be highlighted and discussed. The second segment will present empirical finding about students' attitudes towards science and scientific attitudes. In this final section, discussion will focus on the differentiation in students' attitudes towards science and scientific attitudes with respect to gender, race and educational level.

Research Design and Procedures

The respondents involved in this study survey study comprise 493 Form Two, Four and Matriculation students from several secondary schools. The sampling technique used is stratified sampling (Neuman, 1999). By employing stratified sampling approach, the researcher first divides the population into strata (Form Two, Four and Matriculation). The second step involved is systematically draw sample from each strata. By employing this type of probability sampling, the relative size of each strata can be controlled and monitored by the researcher.

The Instruments

The main data-gathering instrument in this study is questionnaire, which includes: i) an adaptation of attitude towards science questionnaire developed by Gogolin and Swartz (1992) and ii) an adaptation of scientific attitude questionnaire developed by Kozlow and Nay (1976). The attitude towards science questionnaire comprises of 48 items and generates six distinct scores rather than a composite attitude towards science scores, viz. perception towards science teacher, anxiety towards science, the importance of science in the society, self-concept in science, enjoyment and motivation in science. The scientific attitude questionnaire comprises of 23 items, which measures students' critical mindedness, suspended judgment, respect for evidence, honesty, objectivity, and willingness to change opinions. The instruments used in this study have been justified in terms of its validity as well as reliability.

Main Findings

Mainly, it was found that students' attitude towards science is high and there exist significant difference in terms of students' attitude towards science with respect to level of educational experiences. As for the scientific attitude, analysis reveals that overall, Malaysian students possess strong inclination towards respect for evidence and honesty. However, their objectivity and suspended judgment are very low. Detail analysis reveals that students' cultural background has significant impact in shaping their attitudes towards science as well as scientific attitudes. It is interesting to discuss how their cultural and psychological environment shape and orient their perceptions towards science and hence their scientific attitudes. To conclude, the attitudinal profile provides viable information about the status of science education in Malaysia. This is because, the attitudinal profile generated, tacitly reflects not only the effectiveness of the Malaysian science curriculum in resulting attitudinal changes in the students, but also to science teachers whereby they need to reflect upon their content as well as pedagogical content knowledge so that the end product of children's formal science experience is not only students' acquisition of scientific knowledge *(cognitive development)* but also changes in terms of students' attitudes *(affective psyche)* – an aim which is boldly written in the Malaysian science curriculum.

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Students' Alternative Conceptions in Pressure, Heat and Temperature

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Objective

To study the undergraduate physics students' misconceptions about some selected basic concepts in thermodynamics.

Significance of the study

At the core of physics education research is the desire to improve instructional strategies for the benefit of student learning. In the physics community, there has been much research undertaken to this end yielding revealing data about what and how students learn. The identification of various misconceptions has led to new ideas for teaching physics both at the secondary and undergraduate levels.

Heat and thermodynamics is a conceptually rich area of undergraduate physics. From the point of view of misconceptions it seems not to have been explored much. Especially in the Indian context so far there has not been much work done in this area. This has prompted us to undertake the present study.

Theoretical Framework

One aspect of misconceptions is that they are part of a student's line of reasoning (Maier, 2004). A misconception is more than having a fact incorrectly memorized. It originates from an inaccurate/inadequate mental structure that underlies one's thinking of a group of related concepts.

Physics is a very conceptual subject. Misconceptions in physics get developed at very basic levels. It is well understood in the physics community that misconceptions must be addressed if they are to be overcome. If not confronted at right time, they keep floating in the students' conceptual framework even to their undergraduate period.

Ironically, at the root of the development of a misconception lies its remedy. In Piaget's model of intelligence, what is required for sound understanding of a concept is accommodation following a state of disequilibrium. If the student experiences are skillfully guided at this stage, the misconceptions which may develop by way of unchecked accommodation may be avoided or disentangled. In other words, according to this model the way to prevent or resolve misconceptions is to have the learner confront the misconceptions directly with an experience that causes disequilibrium followed by sound accommodation (Maier, 2004). It is thus clear that study of misconceptions could be of great help in instruction, particularly in physics instruction.

The present study is on misconceptions that arise in introductory thermodynamics. We have focused our attention on three basic concepts 1) Heat, 2) Temperature and 3) Pressure. A large number of experiences in daily life is related to these concepts and as a result students develop some kind of naive models about these concepts right from their early school days. When such concepts are taught to the students in a way that does not provoke them to confront paradoxes arising from their alternate models conflicting with the 'standard scientific model', they develop misconceptions. The process of development of misconceptions may also be aided by use of words that mean one thing in everyday life and another in a scientific context (e.g. pressure) and by the learner's inability to overcome non-scientific beliefs.

Previous studies have revealed that the terms 'heat', 'temperature' are frequently not differentiated by students (Errickson, 1985). They do not consider surroundings to be important for an object's thermal history (Tiberghien, 1985). The concept of thermal equilibrium is not well understood by them (Strauss and Stavy, 1983) (Arnold, M. Millar R. 1996). Our study confirms these observations. Further we find that students' ideas of pressure are limited to 'force per unit area' and their model of pressure is essentially that of 'weight of a vertical column per unit area of cross section'

Table 1

Items	Did not Attempt	Correct Response	Incorrect/ Inadequate Response
Heat – Basic Concept	10%	20%	70%
Temperature – Concept	40%	0%	60%
Internal Energy and Total Energy	20%	20%	60%
Thermal Equilibrium – Relation to object material	10%	0%	90%
Thermal Equilibrium – Relation to object size	10%	20%	70%
Latent Heat – Constancy of temperature	0%	60%	40%
Temperature – as an Intensive Variable	30%	40%	30%
Pressure – Basic Concept	50%	10%	40%
Pressure – Variation with direction	10%	50%	40%
Pressure – Variation with location	30%	0%	70%
Pressure at a point inside a container	20%	40%	40%

Research Design

We conducted a preliminary study involving discussions with some undergraduate students. This study gave us clues to the kind of difficulties that students have in the topics of our study. On the basis of this study as well as through discussions with some college teachers, we framed a free response test consisting of open ended essay type or short answer questions. This free response test was administered to a sample of 30 undergraduate students in a Mumbai college. The responses to this test were analyzed. In order to probe students' ideas further, interviews were conducted with a few students. This exercise of free response tests and interviews brought out problem areas and helped us identify misconceptions in a broad sense. With this background, we formulated forced option tests to pin down the misconceptions further. The forced option tests are being given to a larger sample of undergraduate students from colleges in Mumbai. For further confirmation/probing detailed interviews will be conducted with a few selected students.

Findings

Table 1 summarizes how students responded to various items in the free response test. The column 'Items' gives the main concept to be tested through the item. The other columns give the percentage of students who did not attempt the item, whose response was 'correct' and whose response was 'incorrect /inadequate'. The prominent findings are given following the table. We intend to present a detailed analysis in the poster format at the conference.

Many students when asked what heat is, can not go beyond a statement "Heat is a form of energy". Some of them relate it to temperature saying that "Heat increases temperature". Some talk about heat as the energy content of the system. They seem to equate heat with internal energy. Neither any student mentions that heat is a form of energy in transit nor anybody shows awareness that heat may lead to external work.

In case of temperature, some students seem to equate it to its unit "degree centigrade". Some say that it measures the 'heat content' of the body. Some use a kind of 'inverted reasoning' to make statements such as "temperature causes change in heat" or "temperature is the unit which determines particular states of a body".

When asked about internal energy, many students seemed to equate internal energy of a system with the total energy of the system.

Thermal equilibrium is a problem area for the students. They were asked about the temperature attained by a body kept in a hot enclosure for a sufficiently long time. They seemed to say that the temperature attained depends on the material of the body or on its size. The materials stated in the relevant item were copper and wood. Copper being a good conductor of heat, was rated as a candidate for a higher temperature than wood which is a non-conductor. Some of the interesting statements were

"In copper, heat affects inner particles, whereas wood absorbs heat only at the surface".

"Wood will resist the change in temperature".

In case of size dependence some students argued that a larger body will have larger temperature (thinking that larger surface area will absorb more heat and hence lead to a greater temperature) whereas some other students said that a smaller body will have larger temperature (thinking that a given amount of heat will result in greater temperature for a smaller volume. They seem to intuitively think of heat as a liquid and the temperature as level of the liquid.)

The concept of latent heat seemed to have no great problem with students. Most of them answered that the boiling point of water will remain constant even after the gas stove is turned on to a higher flame. But there were some exceptions going for 'increased temperature' argument.

The intensive nature of temperature is not understood by the students. Some of them answered that if a container is portioned in two unequal compartments their temperature will be different.

Most students' ideas of pressure did not go beyond 'force per unit area'. They seemed to have a 'weight of column' model of pressure wherein the pressure changes with the height of the column. While applying the model they do not show any sense of the relative magnitude of the density of air and that of liquid, say water. Due to this 'weight of column' model another misconception that students are led to was that a fluid exerts no pressure on the vertical walls of the container.

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Science Teaching through Computer Assisted Instruction: Research Findings and Insights

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Significance of the Study

The day may not be very far off when most Indian classrooms have a computer. Everyday teaching through computers can then become possible. However, educators, administrators, researchers and parents all have doubts about its real learning value. While no one denies the need for making every student computer literate, there are misgivings about the effectiveness of computers for teaching. We would like to see some evidence that computers in classrooms are more than expensive time-wasting toys; that use of computers for teaching enhances learning in demonstrable ways.

In western countries, a great deal of research has been conducted regarding the effects of the use of computers as a teaching tool on student achievement, attitudes, learning rate, retention, etc. (Cotton, 2001). In India, however, not much research or meta-analysis has been conducted in this field. It would indeed be worthwhile to find out if Computer Assisted Instruction (CAI) has the potential to bring about increased achievement in the Indian context, and how it compares to general classroom teaching.

Science is an important subject in the school curriculum that has two major problem areas that cause ineffective learning:

The Limitations of the Teacher: Most Science teachers have in-depth knowledge only in their chosen elective such as Physics, Chemistry or Biology that is required to teach fundamental concepts in the discipline, but they are hampered in teaching other branches which they must teach anyway. Many teachers are not adept at using quick sketches to explain certain content, or in drawing diagrams in Biology. Some do not possess a big enough knowledge-base to link scientific content with day-to-day examples. For effective teaching of Science, teachers need to collect ample background information, for which they may not have the resources, time, or inclination.

Lack of Audio-visual Aids: Teachers often need to carry several charts, equipment, specimens, etc., even for teaching a single topic effectively. However, often these materials are either unavailable or inaccessible; moreover, teachers do not have enough time between classes to procure and test it for its usability. Hence, most Science classes are limited to uninspiring, and sometimes, incomprehensible verbal lectures.

It is believed that computers can not only help overcome these problems, but the vastly greater potential of this technology as an effective teaching aid will cause a quantum leap in the quality of science teaching and learning.

However, in the past, new technology in teaching-learning has not always proved effective. Most science teaching material available for use by teachers was not able to accommodate the individual needs of the teacher. For example, educational films produced abroad did not match the local curriculum and were hard to understand due to different accents.

Today, general-purpose, easy-to-use software such as Microsoft PowerPoint® has become available. For the first time, *teachers* can easily modify and even produce their own CAI material based on the needs of their own classes.

We therefore need to study afresh the utility of the current generation of hardware and software in teaching-learning, and conduct research on what techniques are effective.

Procedure of the Study

I have trained several M.Ed. student-teachers to prepare CAI material for teaching of specific units of Science at the secondary level. They studied its efficacy in terms of student achievement, interest, and reactions. We chose Microsoft PowerPoint as the presentation medium for its ready availability, ease of learning, and because many teachers have learnt to use it. Several such presentations were developed, both in English and the regional language, Marathi, and tested in various schools. About a dozen such researches have been conducted since 1999. In this paper, I do a meta-analysis of the findings of these researches.

Over the years, my experience with preparation of presentations as also the observations of students and their reactions to the presentations led to the development of several useful techniques of teaching-learning that enhance the effectiveness of a presentation.

Some of these techniques are

1. Content analysis of previously learnt related content and a short initial quiz to jog students' memory
2. Use of advance organizers to provide students with "mental hooks" to attach new learning to
3. Use of principles derived from the theory of multiple intelligences
4. Use of visuals to complement the words
5. Use of interactivities such as "think-pair-share" exercises
6. Use of rhetorical questions, puzzles, quizzes, etc. to stimulate thinking
7. Use of hyperlinks to provide extra information on the topic, as well as to explain some basic concepts for students in need of extra assistance
8. Use of formative evaluation
9. Step-wise instructions and figures specifically targeted to improve diagram-drawing skills
10. Some of these features will be demonstrated through a PowerPoint Presentation.

Research Design

Single group and control/comparison group pretest-posttest designs were used. Efficacy of CAI was compared with regular classroom teaching, studying from the textbook, or from plain text files on the computer. Retention of content over time was also studied.

Findings of the Meta-analysis

- Students were given rating scales or rubrics to rate the usefulness of various features included in the presentation. Most students reacted very positively to these features.
- The response of students to CAI has been overwhelmingly positive.
- It led to greater inter-student interactions.
- 't' tests for comparison of pre and post-test means have revealed that CAI has in every case led to increased achievement.
- Its efficacy has never been found to be less than regular classroom teaching or regulated self-study from textbooks.
- In 92% cases, it has proved superior.
- While visually enhanced and non-enhanced presentations were equally effective in bringing about learning, the former led to better long-term retention.
- Differences were observed in the way girls viewed the presentations as compared to boys. Girls were far more systemic, followed a linear mode of viewing, and took much longer to view the presentations.
- Teachers who saw the presentations were keen on using them in their classrooms.

Insights Derived from the Meta-analysis

- Thoughtfully designed CAI is indeed effective in bringing about learning, but when the teacher is really good, a few students prefer traditional face-to-face teaching to CAI.
- The packages when used in the self-learning/group-learning mode can be a better alternative to bad teaching, but can never replace good teachers. They can only enhance their effectiveness.
- These packages can be best used as visual aids to supplement classroom teaching (shown on a large T.V. or as LCD display.)

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Data Evaluation: An Integral Part of Learning Science

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Significance of the study

Inquiry based learning simulates, at least to an extent, the way scientific knowledge develops and at the heart of any inquiry project is evidence-based reasoning. The process of drawing inferences from observation involves sifting through data, formulating evidence, and coordinating theory with evidence; although this process is at the heart of scientific reasoning ability, and have received attention in cognitive science, a detailed examination of its components, as they are adopted by individuals in content-rich and school-based contexts, is rare (Greeno & Goldman, 1998; Koslowski, 1996; Kuhn, 1993, 1999; Kuhn, Garcia-Mila, Zohar, & Anderson, 1995; Kuhn, Schauble, Garcia-Mila, 1992; Siegler, 1996). While there have been some studies done on scientific reasoning, transferring research to classrooms and school contexts has it own challenges (Klahr, Chen, & Toth, 2001; Toth, Klahr, & Chen, 2000; Toth, Suthers, & Lesgold, 2002). Klahr et al. (2001) describe the challenges of implementing research-based strategies in classroom settings and those who are closely connected with classrooms are well aware of these complexities. This implies that there needs to be exploration of student reasoning situated in school contexts. Such experiences are crucial for teachers as well because they need to learn to develop reasoning skills in the context of messy and real data so that they can guide their students through the process effectively.

Underlying theoretical framework

Data science inquiry projects of any kind, be they guided or open-ended, often involve some ambiguity due to imperfections at various levels and as a result its interpretation can be difficult for beginners. Whether the data is “messy” or not its interpretation constitutes an essential aspect of scientific reasoning process. There would be hardly any debate about the claim that as a result of learning science, students should be able to reason and be able to understand the implications of evidence. However, researchers have shown that individuals have difficulty interpreting anomalous data unless they have the metacognitive ability to reflect on their own strategies and theories (Kuhn et al.1992; Kuhn et al., 1995). While some individuals might be able to develop these reasoning skills on their own as cognitive research has shown, educators can not leave it to chance and need to make the effort to transport them to instructional contexts to help all students develop strategies for examining data and drawing conclusions.

In this regard another aspect of general instructional environment needs attention; that is, writing reports or expressing the reasoning through writing, since this form of communication plays an important part in a typical school context. Writing reports played an important role in the studies included in this paper. The influence of writing on learning science has been receiving attention from researchers in science education in recent years (Keys, 1999; Keys, Hand, Prain, & Collins, 1999; Hand, Hoehnshell, Prain, 2004). Some of these studies show the importance of writing in helping students learn science but we need details about how students make sense of data, how, when, and why they discount information, what they count as evidence, and other facets of the reasoning processes that are demonstrated in student reports. With this as the basic premise, this study examined the written reports of students at different academic levels, such as middle school and freshman year, in the context of a variety of inquiry projects. The purpose of the study was to gain an understanding of the ways reasoning is used by students in making sense of data during various inquiry projects. The research questions for this study are:

Do students draw inferences from data? What kind of justifications do they provide?

Research design and procedure

This is a part of a larger study involving students in middle grades in an urban school and undergraduate students enrolled in a physical science course for preservice teachers. This wide range of participants was based on the dual purpose of providing future teachers with experiences similar to their students and to study teachers’ reasoning process as well. In this way, the study could provide two levels of information: one, about students’ ways of reasoning; two, how the future teachers handle this kind of science teaching. In this report, the results from a part of the data corpus are presented to provide a sense of the preliminary findings from these projects.

Three tasks – two brief and one long-term project – carried out by the sixth grade students and a two-week long weather project carried out by the preservice teachers constituted the source of data for this study. The sixth graders carried out a pH scales and Acid-base activity; they also planned and carried out an Acid rain project over several weeks.

pH scales: In this activity, students tested various household substances for their pH levels and then classified them as acid, base, or neutral.

Acid-base activity: In this activity, students used universal indicator to examine the neutralization of acid and base.

Acid rain project: For this long-term project, the students worked in groups of three or four and designed an experiment to test the effects of spraying coleus plants with acidic, basic, or neutral water for 3 weeks.

Weather project: In this project, (freshman year) students from a physical science course collected data from weather reports on tv pertaining to a research question of their choice. They were asked to incorporate the variables pressure and temperature in their question; aside from that, they were free to investigate the changes according to their interest. They developed explanations for the patterns of changes they observed in the weather variables, discussed their findings with the instructor, received feedback, and submitted reports on their findings.

Data Analysis: The written reports from these projects are analyzed using inferences and the justifications as criteria for coding. These a priori coding criteria are based on the theoretical framework of the study and are guided by the research questions stated earlier in the paper (Miles & Huberman, 1994). Student reports are examined to see if they drew inferences from their observations, if their inferences are correct and supported by appropriate justification or not. The findings are discussed in detail in the following section.

Findings

The simple experimental tasks carried out by the sixth grade students involved making inferences based on observations. The simplicity of the tasks allowed a clear picture of where students used or ignored evidence in their inferences or justifications. It also provided a scope for guiding them toward further developing their thinking skills. For example, in the pH scales task inferences such as the "acids are sour" did not include the anomalous evidence they had from a soft drink, which tasted sweet. As they learned to examine data, in course of the subsequent tasks, the students illustrated a pattern of moving back and forth between valid and invalid inferences and justifications. This is not surprising given that other researchers (Kuhn, 1999; Siegler, 1996; Kuhn et al. 1995;) have found similar instability in inexperienced learners. Feedback on the ways students used evidence and justified their responses or drew conclusions constituted a major facet of this project. It appears that students – both sixth grade and preservice teachers benefited from this experience as their final reports illustrated improvement in two levels: one, they provided justifications for their inferences which was not usually the case at the beginning; two, they considered anomalous data in the process of making inferences.

The sixth grade students were capable of designing their long-term project on acid rain; working in groups of three or four individuals, they identified the independent and control variables to find the effects of acid rain on coleus plants[1]. In this case, they needed some help in operationalizing the dependent variable, specifically, the plant growth. Analyses of the final reports show that while most students could effectively make simple causal connections between variables from their observations, for some the beliefs and attachment to personal data became a barrier to logical inferences and justifications. The outcome of their experiment was contrary to their expected outcome as well as the composite group data, which indicated that the plants did better with plain water and did not do well when sprayed with acidic water. In their case the plant receiving the acidic spray of water grew well whereas the one receiving plain water died and they concluded that the acidic water was better even though they did not expect it. Nevertheless, these students used their own data to support their conclusion, even in the face of anomaly and in spite of the group data indicating a different trend.

This pattern adds a new dimension to Kuhn's (2001) and Kuhn et al.'s (1995) findings since, according them, individuals tend to have more confidence in their beliefs in the face of anomalous data rather than the data itself. In this case, the group believed in their own data even though it showed a pattern opposite to their own belief and to the larger dataset from the rest of the groups.

The reports written by the preservice teachers focused on more complex inquires as they explored the relationships among pressure, temperature, and humidity (this was the most commonly chosen additional variable) as the local weather changed from day to day. In addition to these variables, some students included some other variables in their studies as well. Nonetheless,

[1] They had learned to design simple experiments in their science class earlier in the year.

overall, there were similar patterns in the development of the data interpretation skills of these students as well. Initially, the conclusions overlooked certain inconsistencies in the data but in course of time they learned to address anomalies, became more adept in drawing inferences based on data, and providing justifications based on evidence.

It was obvious that some of the essential aspects of reasoning processes were rare even in the freshman students' reports at the beginning. In order to learn to reason from "messy" data, students need to explicitly focus on this and instruction needs to guide them in the process; students need to learn a new array of evaluation skills for making sense of data involving complexity and anomaly. The findings further suggest that such skills need to be taught over an extended period of time but unless attention is paid to this aspect of learning science, students are unlikely to learn to make sense of data.

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Teacher as Constructor of Knowledge: An Analysis of Teachers' Contribution to the Hoshangabad Science Teaching Programme

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Teaching of science has been undergoing some major shifts in perspective and approaches over the last century. Each major shift has in turn reformulated the teacher's role calling upon her to acquire new skills, understanding of the subject matter and a different order of commitment to the emerging perspectives. How to create conditions that help teachers make these transitions has been a major challenge for innovating groups. The practical success of any new innovative approach crucially depends on how the task of teacher reorientation, involvement and motivation is approached.

In this paper we seek to share the framework evolved, the methods adopted and the experiences gained from the macro scale implementation of the Hoshangabad Science Teaching Programme in context of reorienting, reinforcing and motivating the teachers.

While mainstream science education in India continues to be afflicted by its phobia of the knowledge explosion and obsession with the 'empty vessel' vision of the learner, there have been interesting attempts to break away from the mainstream practice. The Hoshangabad Science Teaching Programme(HSTP) group's motivation was to evolve an effective approach to science teaching rooted in the social and economic challenges facing a developing country like India, particularly in its vast rural areas. Influenced by the new ideas and perspectives on Science Education emerging across the world, HSTP has been an attempt to reinterpret them in the Indian context and engage with the mainstream school system to evolve workable models of practice.

The major trends of Science Education that exerted their influence on the thinking and evolution of the HSTP approach have been:

- Bruner -'The curriculum of a subject should be determined by the most fundamental understanding that can be achieved of the underlying principles that give structure to the subject. (The Process of Education);
- Primacy to the Method of Science leading to the process-product balance debate;
- Science, Technology and Society linkages and issues emerging from that;
- Learner centred concerns- worldview, knowledge constructs, context and milieu, stages of learning;
- Behaviorism vs. Constructivism debate.

About learning and curriculum HSTP has highlighted

- Aim for developing higher order thinking skills;
- Greater emphasis on the social context of learning;
- Understanding of contextual influences on problem solving;
- Respect for learner's struggle to make sense of scientific phenomena;
- Learning less information in greater depth is preferable to covering a large number of facts and concepts with no understanding (less is more);
- Learning not a passive activity in which teachers disseminate knowledge to students in a one-way monologue using the textbook;
- Learners' construction of knowledge through a complex process of interaction with their own knowledge structures, engagements with materials and experiences, and a dialogue with peers and teacher through which meaning is developed;
- Learning by rote and information recall de-emphasized and seen as opposed to developing conceptual understanding and thinking and practical skills;
- Emphasis on development of learning and articulation skills.

Teachers, resource persons and the curriculum designers had to

- Make the transition from the image of a technical expert to one of reflective practitioner;

- Prepare to address new views of content knowledge in a coherent and comprehensive manner;
- Evolve constructivist approaches to teaching and learning covering curriculum designing, text-cum work book and other teaching learning materials, experimentation using local materials and situations, class room architecture and interactions, different evaluation methods, etc.

An important implication of all this was for the teachers. An essential paradigm shift was to look upon the Teacher also as a constructor of knowledge, and no more as a mere transmitter of knowledge. This had important implications for the way the teachers were involved in various aspects of the programme and how their reorientation was attempted.

This paper attempts to share and analyse the essential ways in which this was carried out in the HSTP by

- Addressing teachers' existing knowledge and beliefs about teaching, learners, learning and subject matter;
- Providing teachers with sustained opportunities to deepen and expand their knowledge of subject matter;
- Treating teachers as learners in a manner consistent with the programme's vision of how teachers should treat students as learners;
- Grounding teachers' learning and reflection in classroom practice;
- Giving teachers a major role in developing curriculum and teaching-learning materials;
- Setting in place an elaborate system of regular peer and resource group-teacher interactions with organized feedback collection and equal participation;
- Giving teachers' a central role in devising and implementing an evaluation system in consonance with the larger educational goals of the program.

Major areas of teachers' contribution have been in

- Concept formulation;
- Concept learning and integration with methodology;
- Innovating with learning materials and experiments;
- Constructing a language of discourse with children;
- Evolving methods of classroom and kit management;
- Developing evaluation methods;
- Curricular choices and balance.

The paper and presentation elaborates all this through examples and concludes that an effective implementation of constructivist approach to teaching of science would crucially depend on enhancing and enriching the role of teachers.

[The first version of this paper was presented at the International Seminar on "Construction of Knowledge" organized by Vidya Bhawan Education Resource Centre, Udaipur, Rajasthan; April 16 - 18, 2004.]

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Cooperation between Schools and Universities as a Catalyst for the Professional Development of Teachers

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Objectives and significance of the study

The study is part of IMST², a big scale development project involving about a hundred upper secondary schools in Austria in the years 2000-2004. The two goals of IMST² are

- to improve the quality and efficacy of mathematics and science teaching by engaging teachers and scientists in a common research cooperation and
- to design the conceptual foundation of a support system for schools.

The starting point of all IMST²-initiatives are innovative ways of teaching and learning worked out by teachers and written down in their reports. They work mostly in teams, sometimes combining several subjects (biology, chemistry, mathematics, physics). The teachers choose one of four ways of cooperation with other teachers and with scientists, thereby focussing either on (i) Mathematical and scientific literacy, (ii) School development, (iii) Teaching and learning processes or (iv) Practice-oriented research. In all four priority programmes the teachers formulate the specific goals of their efforts, take part in workshops, discuss about topics of current educational research and share practical knowledge about mathematics and science teaching. The whole project is evaluated as an intervention on three levels: classroom (use of more effective teaching methods, strengthening independent learning), school (teamwork among teachers and progress in school development processes) and the educational system (growing appreciation of mathematics and science in the social environment, professional development of teachers). Two research studies were carried out in order to generate information on how effective a cooperation of schools and university, of teachers and scientists can be for improving the quality of teaching and learning, viz. about (i) changes in attitudes, interests and achievements of students and (ii) changes in didactical approaches and professional practice of teachers.

The second study scrutinizes examples of good classroom practice and its repercussions on the professional development of teachers. To this purpose a set of criteria is developed to assess the teachers' progress. This set of criteria is an instrument for further inquiries into educational innovations.

Underlying theoretical framework

Professional development is understood as a continuous extension of competencies through systematic self-study. It is the capacity to learn and draw consequences from experience and thus balance the complementary dimensions of action and reflection as well as autonomy and networking. A main indicator for the success of IMST² is that teachers extend their pedagogical-content knowledge as well as their methodological skills in evaluating their teaching, in collaborating with colleagues and in reflecting about educational goals. *The central hypothesis of the study is that the importance of reflection and networking is steadily growing in a professional development process.*

In order to describe and analyse a complex intervention into the educational system and its effects on students, teachers and the school setting, the following theoretical approaches are used:

Systems theory (focus on interrelations between individual growth, team processes and organizational frameworks; on schools as "learning systems")

Action research (teachers as "reflective practitioners"; learning from experience; sharing knowledge; taking responsibility; empowering students)

Constructivist theories about cognition (subjective patterns of knowledge and understanding, learning as a social activity).

Research design and procedure

Two case studies are combined with an investigation about teachers' views about professionalism, i.e. about qualifications teachers must have.

The first case study explores and assesses the changes in the classroom routines, teamwork, attitudes and beliefs of a team of mathematics and science teachers who were engaged in a science teaching project about aspects of measurement in mathematics, geography and physics. They collaborated closely with a team of scientists and with each other in their planning and team teaching. In order to describe their professional development in the course of this year, the four dimensions action and reflection, autonomy and networking are subsequently refined into a set of 12 criteria.

As a research method a “triangulation” procedure is used. Three sets of data are collected by interviewing the team of teachers, questioning the students and analysing the field notes of an observer. The results are clustered, categorized and compared. Common features and differences between the three perspectives (e.g. about student interest, participation and understanding) are worked out in order to gain a comprehensive and differentiated view of the process.

A second case study repeats the inquiry with another group of teachers who developed physical and chemical experiments about electricity for their students. They and a sample of their students were interviewed about the sustainable effects of this classroom innovation regarding a deeper understanding of scientific concepts.

The set of criteria for professional development is used to assess the progress of both teams. The results are used (a) as a feedback for the teachers who use them for further planning, (b) to test the validity of the hypothesis about the growing importance of reflection and networking, (c) to draw conclusions for an effective support system for schools.

In an additional inquiry, a group of twenty teachers was interviewed about their views on professionalism. Their statements are categorized and compared with current discussions in educational science publications to test the underlying hypothesis.

Findings

Professional development of teachers is no longer restricted to their classroom practice. They are increasingly involved in school organization and professional communication. This observation backs the underlying hypothesis about the growing relevance of reflection and networking for the teaching profession.

A set of twelve criteria has been developed and is shown to be adequate for evaluating professional development processes:

ACTION AND AUTONOMY Innovative teaching and learning methods Knowledge of current developments in science and science education Provision of adequate learning conditions (resources, atmosphere) Appreciation of students‘ perspectives
REFLECTION Evaluation of the effects of the teacher‘s actions Consciousness of increases in competencies Rethinking of attitudes and beliefs Critical ideas about math. & scientific literacy
NETWORKING Teamwork within school Cooperation with people from other institutions Organizational development Public relations

Active participation of teachers in an R&D-project proves to be a powerful stimulus for educational change, if it focuses on independent student learning, and if it is supported by an expert team.

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Involving Scientists in K-12 Science Education: Benefits to Scientists from Participating in Scientist-Teacher Partnerships

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Over the past decade, collaborations between members of the scientific community and K-12 educators are increasingly seen as a key mechanism of science education reform in the United States. These scientist-teacher partnerships can occur in the context of research laboratories, K-12 classrooms, and professional development settings. The potential benefits for the K-12 system are enormous, including scientist role models for students, increased knowledge of scientific concepts and inquiry for teachers, and the integration of scientific inquiry experiences into K-12 science teaching and learning. But what, if anything, do university scientists themselves learn from collaborating with teachers and students?

This study examines the impact of scientist-teacher partnerships on university scientists participating in partnership programs at two universities: 1) the UCSF Science and Health Education Partnership (SEP), a long-standing institutional partnership at the University of California, San Francisco (UCSF), and 2) the GK-12 Partnership Program, a recently founded program at San Francisco State University (SFSU). Both partnership programs engage teachers from the San Francisco Unified School District (SFUSD), a large, urban school district with a strong commitment to improving student achievement. Preliminary interview data collected from 34 scientists guided the further collection of written response data from over 40 additional scientists. This written data set was analyzed to identify common learning outcomes reported by scientists and to determine the prevalence of each outcome among the cohort.

Analysis of data from participating scientists suggests that scientists benefit from their partnership experiences with teachers and students in a variety of ways that have profound effects on them both professionally and personally. The benefits that scientists accrue from partnership fall into three broad categories: 1) benefits as scientific professionals, 2) benefits as future educators, and 3) benefits as individuals. More specifically, scientists report that as a result of their partnership they interact with colleagues in new ways, reflect on their understanding of or renew their enthusiasm for science, and explore new career paths. In addition, participation in partnerships also affects scientists' attitudes toward teaching and education. Through working in partnerships, scientists develop the ability to explain science simply, explore inquiry-based teaching strategies, and reconsider their own teaching philosophy. Finally, partnerships also affect scientists personally; they gain personal satisfaction, establish connections to the community, and in some cases increase their general confidence and self-esteem. Post-hoc quantitation of these sub-categories demonstrated that each scientist benefited in multiple ways and that emerging outcomes were robust across multiple scientists.

While it has been previously suggested that scientists may benefit from partnerships, this is one of the first studies to explore this issue in depth with a large cohort of scientists. These data suggest that scientist involvement in K-12 partnerships has the potential to drive reform of university science teaching, since many scientists who teach in undergraduate and graduate settings and do so with little or no formal pedagogical training, as well as provide a promising approach in promoting coherent articulation of K-18+ science teaching and learning experiences for students. [Funded by the National Science Foundation, NSF# DGE-0136879]

Focusing Professional Development for Science Teachers on Student Learning

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Objectives and significance of the study

This study investigates the effects of professional development for science teachers on student learning. It is usually expected that professional development programs positively impact student learning, however this dimension is not commonly incorporated in the programs evaluation. It is simply assumed that students will be indirectly impacted through their participating teachers in the work with their students. Two main research questions are addressed: 1) Are professional development programs effective in enhancing student learning in science? 2) What are the characteristics of the most and least effective programs?

Underlying theoretical framework

A theoretical framework for the impact of professional development on student learning has been developed, grounded on Guskey's (1986) model of the teacher change process, and Loucks-Horsley et al. (1998) model for designing professional development programs for teachers of science. This framework centers the whole process of professional development on student learning, and emphasizes the necessity of research evaluating the effectiveness of professional development as a function of its impact on student learning.

An international perspective has been adopted, reviewing literature on professional development for science teachers across the world. As Scott, Stone and Dinham (2001) point out "teachers everywhere enter the profession to serve children" (p.13). What is more, they all struggle to improve their practice and teaching through professional development.

Research design and procedure

To answer the proposed research questions a meta-analysis of 37 professional development programs reporting their impact on student learning was performed. Program characteristics have been defined according to the categories defined by Loucks-Horsley et al (1998), the National Science Education Standards (NRC, 1996), as well as new categories developed by us analyzing other variables such as the length of the program. Moreover, a Fixed Effects Model was used to differentiate between the impacts of the different characteristics of professional development programs for science teachers.

Findings

A significant impact of professional development for science teachers on student learning has been found in the form of an overall correlation effect size of $r = 0.22$ ($p<0.001$). In particular, programs emphasizing work on curriculum development or implementation, scientific inquiry, pedagogical content knowledge, and lasting over 6 month and with a total duration of at least 100 hours have been identified as having a larger impact on student learning.

To enhance the findings vignettes have been developed based on the attained effect sizes describing possible professional development programs. These vignettes are driven by the quantitative results from the meta-analysis. These results are the backbone or framework from which the description usually present in a vignette emerges. Recommendations for present and future professional development programs are made based on what works best in order to maximize their impact on student learning.

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Project Yuva: The Design of a Case-Based Multimedia Environment for Pre-service Teachers

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Introduction

This paper describes the integration of a case-based digital learning environment (*Project Yuva*) into a teacher education course, and the impact that environment had on preservice teacher thinking around teaching science in urban settings with respect to issues of diversity and social justice.

The three cases in this environment are drawn from extensive data gathered from two urban middle schools in New York City as part of a larger project. The cases, presented in multiple formats (video, text) illuminate the issues central to the teaching and learning of transformative science in urban settings. These issues include: (1) students' funds of knowledge and how funds of knowledge relate to science (Bouillion & Gomez, 2001; N. Gonzalez & Moll, 2002), (2) strategies (teacher and student) for leveraging funds of knowledge in science learning (Swidler, 1986), and how students' funds of knowledge contribute to the composite culture of the classroom (Hogan & Corey, 2001). In this environment we refer to the combination of "students' funds of knowledge and the strategies they employ to activate those funds" as their "science toolkits" (see Swidler, 1986; Seiler, 2001). We also refer to how teachers understand students' funds of knowledge, their own funds of knowledge, and the strategies *they* use to draw upon them as their "pedagogical toolkits."

Project Yuva provides preservice teachers opportunities to: (1) Explore urban students' "science toolkits" from multiple perspectives and (2) Generate a set of defensible claims (and to provide concrete evidence for those claims) about teaching science for diversity and social justice in urban settings. It was created with the belief that the addition of this case based digital learning environment in a teacher education course (on urban science education) would provide teachers with a shared context to explore issues related to teaching science for diversity and social justice, in a safe but challenging environment.

Research Questions

Two research questions frame this study for the purposes of this presentation:

1. How do preservice teacher's ideas about teaching science in high poverty urban schools develop over their participation in *Project Yuva*?

2. How do teachers' understandings of what it means to teach for social justice and diversity develop?

Conceptual Framework:

Preservice teachers typically see themselves as "committed individuals, having good parents, good values, a good education, and a good sense of what is expected from them as teachers (McIntyre, 1997). In contrast, they see students of color as not having- as somehow deficient" (p. 135). Many teachers hold on to such beliefs even after undergoing educational experiences that specifically focuses on an anti-deficit approach (Williams, Newcombe, Woods, & Buttram, 1994). Goodlad's (1990) study on teacher education in the US showed that many teachers "were less than convinced that all students can learn. They voiced the view that they should be kind and considerate to all, but they accepted as fact the theory that some simply can't learn." Schultz *et al.* (1996) also found that preservice teachers have stereotypic beliefs about urban children e.g. they believe that urban youth have attitudes that interfere with education.

Over the past decade or so, several educators have revitalized the field of urban science education research with their agenda for social justice and action research (Calabrese Barton, 2002; N. Gonzalez et al., 1993; Hogan & Corey, 2001; Moje, 2001; Moll, Amanti, Neff, & Gonzalez, 1992; Rodriguez, 1998; Swidler, 1986; Varelas, 2002). We believe that these anti-deficit perspectives are an important part of an urban teacher's pedagogical toolkit, and *Project Yuva* presents such perspectives to teachers in a tangible manner through authentic cases from urban classrooms.

Project Yuva is grounded in theories of development research (Brown, 1992; Van den Berg & Visscher-Voerman, 2000)and constructivist case-based environments (Jonassen, Peck, & Wilson, 1999). We opted for a constructivist case-based environment because of its advantages in teacher education: learner controlled environments, opportunities to revisit classroom events, multiple perspectives, and procedural support for instructional design and classroom teaching (Horvath & Lehrer, 2000; Koehler & Lehrer, 1998; Lampert & Ball, 1998; Lehrer, Petrosino, & Koehler, 1999; Merseth, 1996; Van den Berg & Visscher-Voerman, 2000). Also, the non-linearity of multimedia learning environments such as those developed by Lampert and Ball (1998) enhances the effective use of cases by allowing the user to revisit various sources of information and to build and store flexible and multiple links among various pieces of information (Putnam & Borko, 2000).

Methodology

The embedded case study design (Yin, 2003) has been employed in this project, where the course Urban Science Education is the context of the study and 6-8 preservice teachers in the course are the subunits of analysis. Data were collected through participant observations as well as collections of weekly and semester-long assignments, teaching philosophy statements, reflections, and fast-writes. Further, the 6-8 case study participants were interviewed in depth throughout the course of the semester and will be observed and interviewed during their field placements as well.

Findings

In presenting the stories of two preservice teachers enrolled in the course, two key tensions have been traced through the data:

1. A major methodological tension we anticipated (in the design of Project Yuva) is the tension between making a justifiable case for the claims presented in *Project Yuva* around science learning in high poverty urban schools, and the transferability of those claims to preservice teachers' own classroom experiences (in their student teaching and observation experiences). Using the teachers' own stories, we present in this paper, how our preservice teachers were able to negotiate this particular tension to incorporate the claims into their own pedagogical toolkits.

2. Also of interest is the tension between theory and practice omnipresent in preservice teacher education. A critical finding hidden in the preservice teacher stories is the impact that using a case-based environment has on developing preservice teachers' pedagogical toolkits by offering a more tangible understanding of abstract theoretical concepts in authentic classroom settings. Part of the story we tell in this paper is how those understandings were incorporated into the preservice teachers' pedagogical toolkits and further, how they were then drawn upon in the student teaching experience.

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The Design and Development of Cognitive Acceleration through Technology Education (CATE): Implications for Teacher Education

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Introduction

The Cognitive Acceleration through Technology Education Programme (CATE) has been designed to help 11 to 14 year old students develop their thinking and reasoning skills so that they are in a much stronger position to solve more difficult problems that they may well encounter later in the school curriculum. The activities are purely cognitive in structure (i.e. there are no 'hands on' practical or making activities) and such lessons are integrated into the established schemes of work. The authors worked closely with KS3 Design and Technology teachers in order to determine the subject oriented platform from which the cognitive tasks could be developed. Although these tasks were *not* designed to teach concepts or skills directly related to design and technology schemes of work, they did align with a range of focus topics in order for students to feel coherence within the delivery framework of the subject however this might be formulated by the individual schools, and in turn, design & technology departments.

The authors believe much of the success achieved in the pilot schools may be attributed to the methodologies adopted by the participating teachers and in turn the nature and quality of the training they have received. Prior to embarking upon 'CATE teaching', a structured and comprehensive in-service training programme is delivered involving all of the design and technology department within a school. In addition some Local Education Authorities in England and Wales have launched aspects of CATE teaching through a centralised training programme and one of the authors has integrated a study of CATE (including training for classroom implementation) into a BA Ed Design and Technology initial teacher training degree. An evaluation of these training strategies will be reported on within this paper and an indication of the further developments of CATE in light of this will be discussed.

In developing this programme, the authors wished to address questions concerning the effects of the intervention on the students' performance, including the following:

- Would cognitive intervention methodology improve the technology capability of the student?
- Would such an intervention programme improve the general information processing capability of the student?
- Would such an intervention programme allow for transfer into other areas of the school curriculum?

These have been reported on at several junctures of the development period. This gave rise to the need to investigate the effects of intervention methodology upon perceptions of teacher professional development.

CATE Training Strategies

Initial Teacher Training – the key element within initial teacher training both on undergraduate programmes (3 and 4 year) and postgraduate programmes (1 year and 2 year modular) was awareness raising. This was introduced this year as part of the 'learning and teaching' framework across each programme with the opportunity provided for support for students wishing to trial materials whilst on 'school experience' placements. It is too early to provide 'take up' or evaluative data at this stage. However, initial responses have been very positive.

In-Service teacher training – This is phased wherever possible:

Introductory training – primarily for key teaching personnel from schools within local education authority regions and/or of whole departments in schools. Expectations at this level are for participants to gain an understanding of the philosophy and underlying theoretical framework together with an insight into delivery and management considerations.

In-class support – this may include demonstration lessons and certainly includes supporting teacher led delivery. Discussion is ideally with the whole department encouraging individuals to learn from each others practice. Such support is frequently on-going within the first year of implementation usually ranging from 2 to 5 training 'visits'.

'Revival' training – aimed at schools where major staff changes or departmental reorganisation have taken place since the original CATE implementation. The nature of such training is a negotiated variation on the above.

Joyce & Showers (1980) reported that the most effective teacher professional development activities are those that combine theory, modeling, practice, feedback and coaching for application, particularly peer coaching. This was the line adopted for CATE training, though in practice many schools / education authorities have favoured the 'one hit' introductory training experience to be followed by cascade training in-house.

Research rationale and methodology

Design and Technology is a relative 'newcomer' with regard to assimilating a cognitive intervention methodology into its learning domain. It is also a subject predisposed to many perceptions from without and within its subject bounds. The authors wish to determine what effect CATE might have upon such perceptions and the subsequent effect this may have upon the professional development of D&T teachers.

A post-training analysis of evaluative data has been collected over the past two years – this has been the first indicator of possible changes in perception of design and technology teaching roles and subsequent practice. A trial in three schools in 2002 included a more extensive analysis based upon open discussion with participants (all three schools) and individual interviews (two of the three schools). The open discussions occurred during in-school departmental meetings at least three months after initial training. Interviews took place eighteen months after training and introduction of the CATE programme in those schools. Further interviews are planned over the next year to provide a more comprehensive view.

Initial findings

The post-training evaluative data raised many issues whilst in the main conveying much positive feedback concerning both content and delivery styles. Although the questionnaires were focussed upon a broad evaluation of the cognitive intervention methodology, response to a number of statements gave insight into revised perceptions of role, sphere of influence and effectiveness. This was further confirmed and elaborated on by the interview data where in addition, interviewees were given the opportunity to be more reflective about their practice and their original expectations. The authors believe this may point toward a new focus for design and technology teacher education and warrants further investigative study.

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To Identify and Structure Technology that Has Already Crept into the School Curriculum

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The 20th Century has seen an extraordinary growth of information base and development in Science and Technology. 80% of the technologies we shall work with by the year 2050 have not been invented yet. As per current rate, knowledge is doubling every three years. The quantum of knowledge today will grow a million times by the time a seven year old of today reaches seventy. In a decade or two scientific and technological skill sets of higher order will be required for any job. So children of today must have scientific and technological literacy if they are to live productive lives and participate effectively in the work place.

The projection of turn-over in IT in 2007 in India is Rs 40 lakh crores; there will be 22 lakh jobs by then. The parallel growths of technological knowledge and IT have left the school curriculum totally stunned – how much more to stuff in the school bag? Perhaps the solution lies in planning a flexible science and technology curriculum which will use IT for teaching and learning at all levels in the school. In this context portions of the National Policy on Education (NPE –1986) of the Govt. of India concerning science and technology, which will be relevant for our discussion, are reproduced here:

> 'As computers have become important and ubiquitous tools, a minimal exposure to computers and a training in their use will form part of professional education. Programmes of computer literacy will be organized on wide scale from the school stage' (NPE – 6.5).
>
> With the recent introduction of computers in the schools, educational computing and the emergence of learning through the understanding of cause-effect relationships and the interplay of variables, the teaching of mathematics will be suitably redesigned to bring it in line with modern technological devices' (NPE – 8.17).
>
> Science education programmes will be designed to enable the learner to acquire problems solving and decision making skills and to discover the relationship of science with health, agriculture, industry and other aspects of daily life. Every effort will be made to extend science education to the vast numbers who have remained outside the bane of formal education' (NPE – 8.19).
>
> 'In order to meet the continuing needs of updating curriculum, renewal should systematically phase out obsolescence and introduce new technologies or disciplines' (NPE – 6.11).

Technology Policy was announced by the Govt. of India in 1983**.** This Policy foresaw "attainment of technological competence and self-reliance" and "consolidation of existing scientific base and selective strengthening of thrust areas". The Science & Technology Policy of Govt.of India- 2003 has elaborated a 16- point strategy and implementation plans, e.g. S&T governance and investment, optimal utilization of existing infrastructure and competence, strengthening of infrastucture in academic institutions, new funding mechanism for basic research, human resource development, etc. These aims demand development of human resources right from the school level.

NPE – 6.11 stressed the need to update curriculum to phase out obsolescence and introduce new technologies which rule our activities today. This prompted researchers to bring out dimensions like frontline curriculum, cutting edge curriculum, flexible curriculum, renewal cycle of curriculum, ways and means to teach science as 'Science and Technology'. Science education was renamed as S&T education by the UNESCO in the eighties. World Council of Association for Technology Education was set up with UNESCO,s initiative in 1993.

In India, school science textbooks of today have in fact enough *technology* content, though unfocussed and unstructured. This has been analysed in this paper, as this exercise will be able to give input to the research for bringing out the next generation of text books on *science and technology. Technological* terms numbering nearly 300 in books for classes III to V and nearly 900 in science books for classes 6 to 8 were found. Going by the number of lessons carrying technology in the text books of classes III to V, 59%-68% of lessons in Environmental Studies (social studies), 23%-

32% of lessons in English , 14-21% of lessons in Hindi and 50-69% of lessons in Mathematics carry science and technology terms, topics, names of inventors, etc.

If we seriously want to decide the dose of *technology* for the age group 9-14 , we might catch them at this stage for effectively taking part in decision-making process required by any technological community of this century. Terms like satellite communication, mobile phone, internet, microwave oven, fuel cell imply newer technologies reforming older ones like telegraph, telephone, primus stove, lead-acid cell, etc.

For each technological term, establishment of language connection is most important, *Technology* is a typical ally to science. Could the *technological* term be linked with history, geography, mathematics, SUPW/work experience? If, yes, history part of *technology* should go to the history book, mathematics part to the mathematics book, and so on. This will reduce the burden on the teacher and the taught, reduce the weight of the school bag, as well as will contribute to *technological literacy*.

Any curriculum has basically six elements: rationale, objectives, implementation strategies, curricular materials, transaction method, evaluation. It might take a few years to introduce *technology* as a separate subject at the lower and upper primary levels in the school. Just now we should integrate *technology* with science in the S&T text book.

The textbook of S&T must have at least the following sections:

(a) There will be a box giving he list of keywords/ *technology* terms used in the chapter at the very beginning of the chapter

(b) Another box with the title 'hands-on activitity' or 'Quick- Lab' has to be given at a suitable place illustrating how to go about the activity. Such illustration should be 'worth one thousand words' .

(c) A third box will contain *problem solving questions*, which could be *convergent*, *divergent* ,*literal, interpretive* . Success of introduction of technology will depend on the quality of these problem solving questions.

(d) A fourth box will detail the references to resources, eg. Science museum, planetarium, industry, scientists and technologists, laboratories, lectures, science magazines, etc.

Classroom transactions will have a mandatory component of hands-on activities somewhere in the cycle of *pre- plan, focus, teach, apply, re-teach*.

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Placing Technology Education within the Gender Perspective

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The issue

Since ancient time men and women have tried to understand their environment and solve problems of daily life using science and technology (S&T). Women have enjoyed symbolic respect and importance in many cultures. The earliest myths and religions have often placed women at the beginning of technologies of agriculture, law, medicine and timekeeping. Many cultures till today retain the image of the "wise woman", the healer, who has access to natural and supernatural knowledge (Stanley, 1995).

Women have contributed in many ways to the technical advancement of humanity. Indeed women as food gatherers are likely to have made the momentous discovery of agriculture that changed the course of human cultural evolution (Ehrenberg, 1989). Yet, women appear to play the role of users and consumers and not that of designers and developers of technology. Excluded from the community of technology practitioners, even women's contribution to technology is *hidden from history*. Their areas of contribution, like child rearing, housekeeping, nutrition and agriculture, are deemed to be either non-technological or low in technology (Wajcman, 2000). Historically, women have had limited access to education and technological practices. There are a variety of complex social and psychological reasons for this situation where only a few women enter the fields of education or work explicitly labelled S&T (Schiebinger, 1989; Zuga, 1999).

Alternate positions

Any technology is the product of society, of social relations, forces and choices shaped by social arrangements. The gendering of society in general and school education in particular has important implications for women's role in knowledge and technology production. In India, like elsewhere, till not too long ago, women were excluded from the formal education system of which the Indian *gurukul* system is an example. Within the institution of education, discrimination and exclusion of women in areas considered S&T may have apparently reduced, but persists in subtle ways.

One way in which this gendering is implemented is through the use of language and stereotyping at all levels from toys, educational software to occupations (Kalia, 1986; Bradshaw et al., 1995). According to Wajcman (2000), S&T are popularly viewed as masculine, with the engineering culture epitomizing this masculinity. The transaction in S&T classrooms reflects these views (Jones, 1989; Sadker et. al., 1989). Hands-on-experiences in S&T, tool usage or real life experiences which could facilitate learning of S&T, differ among males and females in and out of school (Chunawala and Ladage, 1998; Jones, et. al., 2000; Sjoberg and Imsen, 1988).

The "Pupils Attitudes To Technology" (PATT) studies conducted since early 1980's have highlighted the role of gender in students' perception of technology education in several countries (de Klerk Wolters, 1989). Other literature also suggests that male and female students bring in, hold or leave with different attitudes towards S&T education. (Rosser, 1993) However, there are few studies in the Indian context on students' ideas about technology.

The decrease in women's participation in S&T is sharp in tertiary education (World Education Report, 1995, Parikh and Sukhatme, 2004). There is a need to challenge gendered perceptions and practices of technology in schools so as to overturn traditional ideas about masculine and feminine roles and bring about a richer and more inclusive view of technological activities.

Our framework

India, has recently introduced technology as a part of school science curriculum. Technology in the school curriculum has had a chequered history in India. It has appeared in the guises of vocational education and "Socially Useful and Productive Work" that have been stereotyped on the basis of gender. Technology taught to girls has been limited to food or domestic work, such as, sewing, embroidery, tailoring, cooking and nutrition while boys have been restricted to bookbinding, carpentry, electronics. Overall technology related subjects included in Indian schools have been given a low priority by curriculum framers, who reflect the prevalent perceptions.

At the Homi Bhabha Centre for Science Education (HBCSE) a project on Design and Technology education at the middle school level has been undertaken. One of the aspects of the study is to elicit the perceptions and attitudes about technology among middle school students and teachers. This is followed by development of prototype classroom intervention units on technology tasks for school students.

A survey of urban and rural students in and around Mumbai city sought to uncover middle school students' spontaneous ideas about technology. The questionnaire utilized various formats of questions including a pictorial component similar to that developed by Rennie (1995). The analysis of this survey provided interesting insights into students' perceptions of technology and the gender dimension of these perceptions. The paper will present and discuss the implications of the findings relating gender and technology.

A significant component of the study is the focus on *gender sensitive* technology education. Several issues are involved in developing intervention tasks that are inclusive for girls and boys: nature of tasks, the ordering of activities within the tasks, the structure of the groups that collaborate, the process of group formation and the nature of communications and interactions that are facilitated. The paper will explore the development and trials of meaningful technology education tasks in urban and tribal school settings with reference to issues of gender.

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A Study of Laptops in Science Education

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Purpose and Theoretical Framework

A study of laptop computer use in K-12 science was conducted using the criteria of infotech hierarchy of use (Owen, Calnin, and Lambert, 2002), models of laptop use (Concentrated, Dispersed, Class Set, Desktop, Mixed) (Rockman Et Al, 1997; Belanger, 2000), and grade level (elementary, middle, secondary). (Laptops include Notebook, Powerbook and Pen-point computers.) According to Owen, Calnin, and Lambert (2002) an "infotech curriculum is more than just an alternative to computer education approaches that have been traditionally offered in schools. There is a move away from a situation where the teacher has the major control over the knowledge acquired by students. The infotech curriculum is a quadratic involving teacher, students, content, and notebook [laptop computer] use. In an infotech curriculum, students have individual access to their own notebook computer which is integral to the day-to-day learning activities planned by the teacher...[and] students come to regard the computer almost as an extension of themselves" (p. 137). Advantages include increased opportunity for independent learning, problem-solving skills and research skills. Owen et al. (2002) described the following hierarchy of computer use in an infotech curriculum: Support (e.g., database management, graphic presentation), Link (e.g., email, videoconference), Resource (e.g., researching the Internet), Tutorial (e.g., drill and practice), Curriculum Adjunct (e.g., subject specific data analysis, graphing), Curriculum Alternative (e.g., robotics, mathematica), and Exploration and Control (e.g., simulations). This is a comprehensive hierarchy, and it takes into consideration complex science skills and processes, and provides a systematic way of looking at laptop computer use in science classrooms. See Owen et al. (1997) for a more details on the infotech hierarchy.

Procedure

The analysis sample (N = 16) resulted from a systematic search of the ERIC and WilsonSelectPlus databases. The sample represented North America, Asia, Australia and Africa. The sample was analyzed using the infotech hierarchy of use, models of laptop use and grade level use.

Findings and Discussion

Findings indicate the following: Laptop computers are often used in secondary classrooms for preparing and presenting student projects, data management, decision-making, inquiry activities, and problem-based learning, with improvement in student achievement and writing skills. Laptops are also used for outdoor activity-based science instruction. Minority and disadvantaged students tend to benefit from laptop use, and their participation in science learning improves. Students with learning disabilities seem to improve study strategies as they access and manage information with laptops. The kind of input (key board, induction pen) seems to have an effect on problem solving in chemistry. Whether these are novelty effects caused by widespread computing is an important question. Also, whether the laptop by itself, or in conjunction with other multimedia presentation software, impacted the outcomes is uncertain (Siegle and Foster, 2000). About 75% literature sources analyzed are from North America which indicates inequity in laptop use. How to enable developing nations to reap the benefits of ubiquitous technologies is an important question with implications for science education, technology and socio-economic policy. The small sample size in this analysis shows the need for more evaluative information on laptop computer applications in science education.

Ubiquitous technologies such as laptops should not be touted as a panacea for science education reform. "Technology is… neither intrinsically effective nor ineffective in improving education" (Schneiderman, 2004, p. 33). They offer great hope for improving K-12 science teaching and learning, provided more higher level infotech curriculum applications (Curriculum Adjunct, Exploration and Control) are developed and implemented with increased accessibility across socio-cultural barriers.

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Design as Drawings: Analyzing Drawings of Middle School Students in Technology Education Tasks

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Objectives

Technology tasks engage its participants in a variety of activities: investigation, planning, designing, modelling, making, and evaluating. The study reported here is a part of the broader goal to develop design and technology education modules that will engage middle school students in the classroom. The sequence of actions closely resemble technology task model that have been used in UK and Australia (Kimbell 1996).

Design is at the core of technology activities (de Vries, 1997). There have been a number of attempts to arrive at a theoretical framework for design (Houkes et al, 2002), and to articulate its methodology and role in collaborative learning contexts (Pieters, 2004). Drawings have several roles in design besides making it explicit. This article focuses on middle school students' evolving drawings as they engage in design activities within 3 different technology tasks developed by us.

Theoretical framework

Cave paintings, cartographers' representations, designs and sketches of cathedrals and bridges, illustrations capturing the details of animal, plants and insect anatomy, all show that humans have always used drawings to communicate their ideas. These productions also reflect their socio-cultural contexts. Drawing has been a creative engagement central to every facet of visual arts (Callaway and Kear, 2001).

This report draws from discussions of technology task as a vehicle for multiple modes of expression, and the situatedness of such tasks (Natarajan, 2004). Several studies provide insights about the implications of drawings in learning. Drawings are instruments of thought and serve to clarify features of an idea (Albarn and Smith, 1977). Drawings have been used to probe psychological states (Serendip, 2004), to elicit ideas of people, and specifically, of students (Mehrotra, 2003; Natarajan et al, 1996; Chunawala and Ladage, 1998).

Despite the rich potential of drawings for learning, these have been neglected in Indian school curricula: introduced at the primary level, disappearing at the secondary school level, except as mere reproductions of scientific drawings, geometry figures or geography maps. As for design drawings, there is little scope for its practice. Attempts to see craft and art as essential for shaping an individual (Gandhi, 1968) have been all but forgotten.

Drawings manifest ideas and intentions in the design of a product – through "rough" sketches, "technical" drawings and "procedural maps". Though limited by students' skills, drawings give a glimpse of students' ideas that may be otherwise difficult to infer from verbal descriptions or actions. Drawings make ideas explicit for negotiation among designers or between designers, makers and users.

Research design

Three technology intervention tasks were planned: making a bag to carry school books, a windmill model to lift weight, and making puppets and staging a puppet show. The duration for each task varied from 10 to 15 hours. About 20-25 students of classes 6 and 7 (age 11-13 years), from each of 3 schools, participated separately in the three technology tasks. They represented 3 *clusters*: Urban English and Marathi medium clusters, and a cluster from a government run residential Marathi medium school for tribal students. Each *cluster* of students worked in 6 groups: 2 mixed groups (2 boys+2 girls), 2 groups of boys and 2 groups of girls. The tasks evolved as the students adapted to them and collaborated with their peers and the researchers to complete each task (Rogoff, 1998).

Each task involved diverse skills, some familiar school experience (drawing, measurements, etc.), and some new skills. Data collection tools included observers' notes, complemented by researchers' comments, audio and video recordings. Communication of design and oral descriptions were rich sources of data. Each group filed their paper-pencil productions: descriptive writings, poems, evaluation sheets, and all drawings. Thus, the three technology tasks provided opportunities for multiple modes of expression.

Some findings

In general, the paper-pencil work of urban Marathi medium groups was neater. They drew tables to represent data and information, and procedural maps, to relate drawings with their descriptions. They showed more confidence than other groups in putting down their thoughts, as seen from the fewer erasures in their work. Most groups made more than one sketch, and some even made models. The tribal groups were less distracted (more focussed on the task) in all their activities. However, they showed diffidence in producing drawings, and had problems in relating drawings and their descriptions.

Though the initial drawings of objects reflect students' imagination, they also indicate that students are unfamiliar with the rules of 3-dimensional (3D) drawings. There were some improvements in depicting 3D ideas in each subsequent task.

After exposure to aspects of technical drawings, students incorporated these immediately in their productions: showing dimensions of objects by suitably positioned lines and arrows, and writing dimensional values and units. They continued to use these techniques in their later technical drawings as well as in procedural maps, and not in free sketches, showing that they had possibly integrated this *language of technology*.

Urban students' sketches indicated the variety of products envisaged by them. Their designs for bags included different structural (material, shapes, sizes) and decorative (laces, pictures, coloured paper) elements. For the windmill blade, they depicted a variety of components in their drawings (spoon, foil, cardboard, etc.). However, no urban group included aspects of durability and rigidity for this task. While urban English medium groups did not draw or write about their assembly, among the urban Marathi medium groups there were sketches of different ways of assembling components. All the tribal groups used uniformly similar designs, including structural shapes and materials for the windmill task. Differences were seen only in the details of dimensions and decorative elements. Notably, they also showed aspects relating to rigidity. The tribal groups used their textbooks as a resource to come up with very detailed and varied drawings for the characters in the puppet task.

The evolution of students' drawings through the three technology tasks indicates that exposure to design activities in the context of different technology tasks helps students understand the different roles of design. The roles may include preliminary ideas about the object to be made, recognising that there are alternatives, the variety of components and skills needed for their own design, and use of design as a plan for making and coordinating each others' work. The extent to which these roles will be understood will depend on the rich experiences students get through a variety of design and technology tasks.

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Visions and Mandates: An Analysis of Three Indian IT Curriculum Guides

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Objectives and significance

In this paper we offer a rhetorical and pragmatic analysis of three official documents pertaining to Information Technology (IT) integration into educational practices in the Indian context. The three documents are (a) *the Curriculum Guide and Syllabus for Information Technology in Schools (CGSITS, 2000)* developed and published by the National Council for Educational Research and Training (NCERT). (b) *Modules of the teacher education educational technology curriculum developed by the Indira Gandhi National Open University (IGNOU); and* (c) The syllabus for educational technology master's program students at Shreemati Nathibai Damodar Thackersey (SNDT) Women's University at Mumbai. The NCERT document offers the first national technology curriculum framework for schools (and to a lesser extent school teachers). The IGNOU curriculum is aimed at school teachers while the SNDT course is designed for the next generation of educational technology designers.

The significance of this analysis grows out of three general trends about the direction of the use of IT in education in India. First, despite the arguments about the promises and perils of educational technology, no one can seriously question the growing role of computers and other new information technologies in the lives and learning of teachers and students both in and out of the classrooms. Second, in the case of India, recognition of this role of IT is combined with internationally growing status of India as a computing powerhouse. The push to integrate technology into Indian schools, therefore, is not surprising. This push is manifested through: attempts to develop technology-based curricula for schools; integrating technology into teacher education and professional development; and through educating a breed of educational technology designers. However, given the costs of acquiring, implementing, and maintaining IT, thoughtless investment in educational technology may turn out to be an expensive mistake.

Finally, as the tradition goes, before the imperative to integrate technology in education begins to permeate the schools it is formulated at the highest official levels in our society. The three documents that we have chosen express such formulation in India. Documents such as these, frame the agenda as it were, for schools, teacher education programs and educational technology graduates. Of course this "frame" influences decisions on hardware and software purchases, strategies for teacher professional development, formulation of teaching objectives, as well as the development of learning opportunities for students.

Guiding Assumptions

Our analysis of these documents is guided by the following assumptions:

1. Curriculum guides often contain important implicit and explicit assumptions about students, teachers, learning and teaching processes and their organization, and the nature and role of IT in learning and teaching the school subjects.

2. In any educational innovation guided by technological innovations that take place outside the formal system of education, it is possible for 'orchids and turnips to exist side by side.' That is old is hybridized with new in myriad different ways, sometimes fruitfully and other times in ways detrimental to the learning.

3. Educational system in the postcolonial societies is still regulated or organized largely by a centrally controlled bureaucratic system. The curriculum frameworks and course guides for teachers assume an added importance in one such system.

Given this, we explore the implicit and explicit assumptions in the above-mentioned documents. We then take a look at how those assumptions are articulated in the proposed competencies, knowledge, and skills for teachers and students. Finally, we offer an analysis of contradictions between the visions offered by these documents in contrast to the manner in which they are turned into mandates.

Method of analysis

To perform this analysis, we have resorted to the standard qualitative content analysis (Bogdan & Biklen, 1998). We have developed a set of codes to sort data across and within the documents in accordance with:

1. assumptions associated with the nature and scope of IT
2. assumptions about learners and teachers, process of teaching and learning
3. assumptions about the relationship and role of IT in learning and teaching.
4. the competencies desired and required in learners and teachers
5. activities suggested to develop the stated compet encies

Based upon the above-mentioned assumptions, our analysis of these documents examines the ways in which the assumptions about content, pedagogy and learning, and technology are permitted to interrelate [or not] in the above-mentioned documents. We consider these aspects as the manner of conceptualization of each of them influences decisions on hardware and software purchases, strategies for teacher professional development, formulation of teaching objectives, as well as development of learning opportunities for students.

Results and implications

Following this approach, we argue that there is a fundamental split between the almost utopian visions offered by IT and the manner in which these visions are to be realized. The formalization of IT curriculum in India, which we examine in this paper, may undermine the dynamic [and integrated] practices that have contributed to the development of Indian IT capital. By characterizing IT integration as acquiring a laundry list of functional skills and knowledge, the curriculum guides ignore situational and contextual realities of using technology for learning. This emphasis is akin to what Lankshear (1997) describes as a form of applied technocratic rationality, a view that technology is self-contained, has an independent integrity, and that to unlock its potential and power requires merely learning certain basic skills.

Finally, we suggest some ways by which to replace the technocratic rationality by an inclusive vision which might help blend technology, content, and pedagogy. We also show how such blending may open up new ways of thinking and new problems to solve on the horizon of thinking about integrating technology in education in India. We also suggest some ways in which alternative curricular visions might help retain, foster, and transfer the dynamism of Indian IT revolution to its classrooms.

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Outreach in Engineering Education: The GK-12 Learning Partnership Program

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Goals

1. To foster the cooperative efforts of a practicing teacher, university faculty, a graduate student and undergraduate student in the implementation of problem centered, interdisciplinary learning environments that focus on the application of mathematics to earth science and engineering for middle school students;

2. To enrich the teacher preparation experiences of undergraduate and graduate students who are interested in pursuing pre-college or college education as a potential career;

3. To enrich the content, application and interdisciplinary knowledge of practicing science and mathematics teachers with respect to the application of mathematics to earth science and engineering, and;

4. To enrich the learning experience of middle school students by creating problem centered, interdiscipli-

nary learning environments that focus on the application of mathematics to earth science and engineering.

Background

Concerns have been raised with respect to the low level of scientific and mathematical literacy in the United States society and schools. These concerns are based on U.S. students' poor performances on standardized tests [1]-[4] and have resulted in a range of reform efforts (e.g., [5]-[9]). Teaching and learning standards have also been developed in science [10]-[12] and mathematics [13]-[18], as a foundation to support reform.

At the very heart of reform lies the belief that student learning occurs through exploration and problem solving [19]. Many [2],[20]-[21] have criticized available curricular materials as failing to provide real world examples that prepare students to move from concrete to abstract reasoning. Evidence suggests that elementary and secondary mathematics and science teachers' content knowledge is often incomplete and/or fragmented [22]-[27]. Adding to this problem is the large number of teachers providing instruction in a field other than the one in which they were certified [28]-[29].

Design

GK-12 Learning Partnership is a collaborative between the Colorado School of Mines and Adams County District Fifty and is partially funded by the National Science Foundation (NSF, DGE-0231611). This three year project began in August, 2003, with seven graduate students and seven science or mathematics middle school teachers attending an eight day summer workshop. At the end of the workshop, each graduate student was paired with a teacher and these teams worked together throughout the academic year. An undergraduate joined three teams in January, 2004. Graduate and undergraduate participants will be referred to as "fellows" and have been drawn from the following academic departments: Mathematical and Computer Sciences, Engineering, and Geophysics.

Assessment

Several different formative evaluation techniques were used by the external evaluator: unannounced observations of the summer workshop, comment cards collected from the teachers and fellows during the summer workshop, and focus groups with participating fellows. Summative evaluations were also completed: a pre and post multiple choice content assessment, a range of surveys and questionnaires, and student scores from the Colorado Student Assessment Program (CSAP). This section describes the assessment results by goal for the first year.

Goal 1

Observations during the summer workshop and comments made by fellows and teachers supported that cooperation between teachers and fellows began almost immediately. During fall focus groups, graduate fellows reported that they were respected members of the teaching team. The bonds between the fellow and the faculty workshop instructors were reinforced throughout the year through on-going fellowship workshops.

Goal 2

One of the graduate fellows is currently considering teaching at a pre-college level and four are considering teaching at the college level. The undergraduate spent far less time in the classroom and at the end of the spring semester were uncertain as to whether they would pursue teaching as a career.

Goal 3

On the first and last day of the summer workshop, the teachers took a multiple choice test. From pre to posttest there was a significant increase in the mean scores ($\underline{p} = .004$). A disappointing result was that the mean pretest score was eleven and the mean posttest score was fourteen points out of twenty possible points. Although this indicates that the teachers had not yet mastered the material, the reader is reminded that the workshop was only eight days long.

Goal 4

During fall and spring focus groups, the undergraduate and graduate fellows described a number of activities that were problem centered and interdisciplinary in nature. The participating teachers also expressed that the graduate fellows had a strong impact on their students and that they were successfully implementing problem centered, interdisciplinary learning environments in the classrooms.

CSAP scores in mathematics and science at each participating school were examined for the academic year 2002-2003, immediately prior to the start of this project, and 2003-2004, immediately following the first year of the project. These are displayed in Table 1. There has been very little change in students' overall CSAP performance in mathematics and science at the participating schools. The reader is reminded that the displayed values include entire grade levels within a school and are not restricted to the students whose teachers participated in this project. The investigators are working with the State of Colorado on the possibility of examining CSAP scores of students whose teachers are directly involved in this project.

Table 1 : Participating Schools CSAP Scores In Science And Mathematics

	Mathematics						Science	
	6th grade		7th grade		8th grade		8th grade	
	2002-2003	2003-2004	2002-2003	2003-2004	2002-2003	2003-2004	2002-2003	2003-2004
School 1, Proficient or Above	28%	25%	32%	21%	13%	24%	20%	28%
School 2, Proficient or Above	26%	25%	15%	18%	25%	20%	30%	30%
School 3, Proficient or Above	31%	46%	29%	26%	31%	28%	27%	40%

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Introducing Design and Technology in School Education: Legitimising Multiple Expressions in Classrooms

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The issue

Indians are manifestly capable of adaptive use of modern technologies. Yet, India consistently rates low on significant technological innovations (World Science Report, 1998). Among the people concerned about the problem, some lament that school curricula disregard the nation's cultural heritage of technology productions, and others that education fails to empower the country's populace with such productions (Kothari, 2001).

Technological innovations involve multidisciplinary perspectives and multiple skills. Appropriate training beginning at the school level is the key to creating experts and citizens capable of innovations. Indian school education with its narrowly defined curricular subjects includes little problem solving, and aims at mere technological literacy among students. The classroom communication is severely constrained by content and language of the textbooks. This education also alienates a majority of students from their environments, suppresses their natural and culturally rich modes of expression and stifles local technological innovations. Enriching school curricula with explicit opportunities for multiple expression modes valid in a variety of classroom contexts will not only help meet the need for future technology innovators, but could also redefine the role of school education itself, and potentially the cultural identity of the society. This premise drives the programme of design and technology in school education at the Homi Bhabha Centre for Science Education on technology education at middle school level.

Alternate positions

The classroom context is often thought to be a given in any particular educational set-up. Cognitive studies drawing on the work of Vygotsky and Piaget, and evidences from recent anthropological studies indicate that the context of learning, including peers, teacher, classroom, school and the social setting, plays a crucial role in the acquisition of knowledge and competencies (Brown and Duguid, 1993). Important inputs for reshaping the context of learning come from research in situated cognition (Norman, 1993; Clancey, 1995) and situated learning (Wenger, 1993; Rogoff, 1998). These studies present the acquisition of representations of knowledge, procedures and competencies as necessarily determined by the context in which they happen.

Recent studies have unearthed that the social differences that exist among different cultures affect the nature of their cognitive processes (Nisbet et al, 2001). The history of engineering drawings demonstrates that the modelling methods available to designers do directly affect the potential content of their thoughts (Baynes, 1992). Design and technology activities provide the discourse space and cultural environment that support the use and learning of technology-specific language.

The problems of mismatch between culture, human developmental needs and education are exacerbated in the teaching of science and technology through nation-wide uniform curricular frameworks. These curricula neither explicitly connect with local contexts nor value local knowledge and varied ways of expressing (Chunawala et al, 1996; Natarajan et al, 1996).

Design and technology activities not only draw upon the knowledge of key concepts characteristic of technology – concepts traditionally taught within other disciplines like the sciences and the arts – but also need a variety of skills. Besides, the activities integrate aspects of affect (wants, desires and aesthetics) and judgements (making strategic alliances, choosing materials and evaluating products). Thus, technological activities go beyond addressing episteme (knowledge) and techné (skill), and include phronesis (practical wisdom) (Dunne, 1993).

Our framework

In multi-cultural India, design and technology tasks that evolve within the classrooms, negotiated by students and guided by sensitive teachers, can help connect with the immediate social context, and make use of multiple expressions and appropriate technical tools. The introduction in the classroom of the repertoire of expressions within design and technology (D&T) has the potential to legitimise multiple expressions. D&T curriculum can be inclusive rather than an exclusive endeavour for mixed ability students in different cultural settings, and in diverse multicultural classrooms across the country.

The D&T project discussed here addresses the development, of possible classroom situations that engage students in using knowledge, skills (thinking, manual, procedural, artistic, social, etc.) and values (aesthetic, social). It is envisaged as an action research project having several phases. In the completed first phase, a few design and making tasks have been developed through participation in three school settings. The meaning of the task goal set by researchers and the plans for achieving the goals were negotiated among the students – about 20 per school from Std. VI and VII. The 3 schools were set in different socio-cultural and linguistic environments. Diverse strategies and skills are used by students to complete the tasks. Different modes of expression by students – sketching, drawing, model making, verbal and non-verbal negotiations, oral communication and acting out, and writing in point form, descriptions, and poems – have been integrated in the activities involved in the tasks, and these are observed through a variety of data collections methods.

The second phase will appraise the D&T tasks carried out in terms of their educational goals and content. It will also address the socio-cultural and gender appropriateness, and cognitive suitability. In the third phase, additional and complementary D&T tasks will be developed. In this phase, the modules will be carried out during school hours with the help of teachers. The learning package so developed for students of a specific class would make up a *design and technology education module*. In a longer term, the study is expected to lead to the development of a collection of *D&T education modules* for Indian students at the primary and middle school levels.

Contextual answers must be sought for several questions before D&T education can serve its intended purpose. These include level of school education (pre-school to secondary) at which to introduce D&T, the content and pedagogy at each level, and its relation with existing subjects. The potential of appropriately taught D&T to enhance the learning of other subjects, when proven, will serve to support its introduction as a school subject. Considering the large numbers of both students and teachers in the Indian educational system, methods need to be worked out to orient teachers to teach for D&T capability, beyond mere technological literacy. Integrating socio-cultural and equity aspects in D&T practice need to be clearly spelt out and incorporated in the curricula. A few of these issues, especially the diverse modes of expression and socio-cultural differences have been addressed in the first phase of the action-research project. Some of the deeper issues will need continued research in the area.

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Early Exposure of Pre-College Students to Information Technology

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It is known that information technology plays an important role in employment and productivity of current U.S workers and will do so even at a faster rate in years to come. Yet, the exposure of pre-college students to the technology has been very slow. This is even more evident in some of the major city school systems where inadequate facilities, poor infrastructure and ill-trained teachers have contributed to further deterioration of any planned educational activities in this area. This paper highlights a program that was recently instituted by a non-profit organization, in collaboration with local universities and industry partners, to address the problem and expose pre-college students to information technology and related STEM disciplines. The program is based on past research on students' learning through hands-on activities. Preliminary assessment of the program outcomes is presented in the paper.

Objectives and Rationale

There is no doubt that unfamiliarity with information technology (IT) discipline will limit students' educational opportunities and their future economic status (Gannod, 2003; U.S. National Science Board, 2004). This is nowhere more evident than in the U.S. where current data and future projections show that IT will play a crucial role in increasing the nation's productivity and creating a productive workforce.

It is true that more and more U.S. schools are equipped with computers and associated facilities compared to the scenario that existed in the mid-1990 (National Education Association Homesite, 2004). However, the utilization of computer technology has been limited. A recent study of utilization of computer technology in high schools showed that the primary use has been for word processing and Internet access (Gupta and Houtz, 2000). The study also revealed that students seldom use the technology for learning or developing skills in area of programming, information storage, data manipulation and retrieval, web page development and for communicating through graphics. Graphical communication is a concise language used by scientists, engineers and technically skilled personnel. The lack of properly developed technology education and utilization, combined with a lack of interest on the part of students to pursue science, technology, engineering and mathematics (STEM) based career, has been a national concern in the U.S. for quite sometime. Motivating high school students to pursue technical career has been a challenging task and large metropolitan city schools have not been very successful at the challenge.

Because of this, the Detroit Area Pre-College Engineering Program Inc. (DAPCEP), a non-profit organization, in collaboration with several local universities and corporations, developed a program in IT and related disciplines. The objective of the 4-year, 2-cycle project is to provide hands-on education and skills opportunities to underrepresented minority students in middle and high schools from the Detroit area. It allows the sponsors and university participants to assess if the approach would help to elevate IT skills amongst pre-college students in predominantly minority schools. The major funding for the project is provided by the National Science Foundation (NSF) under the Information Technology Experience for Students and Teachers (ITEST) program. The University of Michigan-Dearborn (UM-D), along with the University of Michigan-Ann Arbor (UM-AA), Michigan Technological University (MTU), University of Detroit-Mercy (UD-M), Lawrence Technological University (LTU) and Ford Motor Company (FMC), are providing the majority of instructional and laboratory activities to student participants.

Project Design and Procedure

The project was designed to provide educational activities and hands-on laboratory experience over a 2-year period to students starting in the 7th and 9th grades. An extensive process was developed to admit students into the program. The admitted students were required to make a two-year commitment to the program. The major focus of the project is IT; however, other related activities including uses of IT in the sciences, mathematics and related disciplines are included as part of the project. These activities are crucial to a successful career in the IT arena or application of IT in STEM disciplines. The two-year program at each grade level includes six Saturdays of classes in autumn and spring each and a four-week program each summer, for a total of about 150 hours of instruction and activities per year. Research has shown that students' learning is more effective if it is accompanied by hands-on activities. The UM-D project included evaluation of effective modes of learning IT and related skills in a classroom and laboratory environment.

A partial list of topics covered and assessed at UM-D in year No 1 is listed:

- Development of short computer codes with simple algorithms, storage and retrieval of code on a server, use of security to access, modify and restore code or similar information.
- Use of database to store, retrieve and sort information; present information through various graphical modes of communication and presentation data and results through text, oral and graphical communication.
- Use technology to analyze experimental data, present and communicate results through IT, and develop alternate methods of storing and presenting the information.
- Use of Internet and development and use web pages for business and marketing, for storing and retrieving information, and for communication

Preliminary Findings

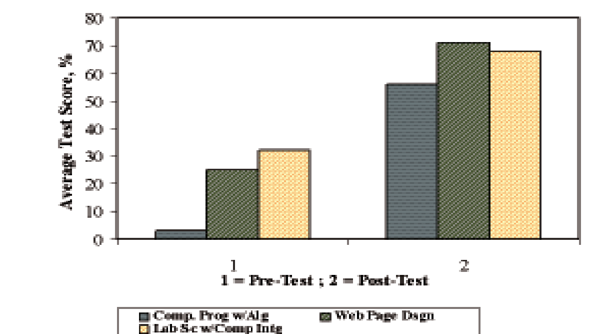

Fig. 1 Performance on Pre and Post Test

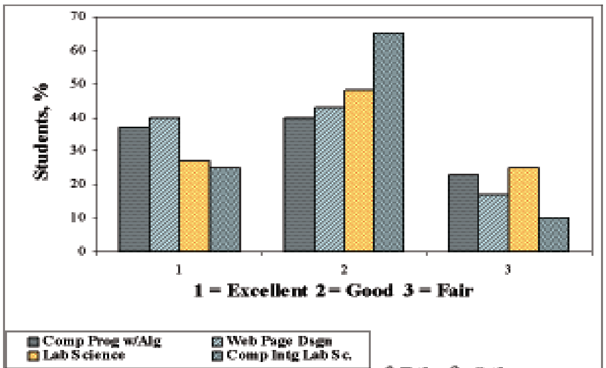

Fig. 2 Performance of 7th & 9th Grade ITEST Students

The project target areas were assessed by an external evaluator to determine improvement in participants' knowledge and comprehension of the topics. This evaluation was done through various approaches, one of them being the pre and post-test performance. Figure 1 shows impact of instructional and hands-on activi-

Task Name (No of Students)	Instruction & Learning	Skills Development
Storage & retrieval to/from server (60)	Small group Inst/Learning	Small group
Computer code/program development (30)	Small group and individual	Individual
Conduct lab exp and collect data (48)	Large or small group	Team
Data reduction/analysis, store/ret/modify (48)	Team	Team
Creation of simple web page (30)	Large or small group	Individual
Use of data base and data manipulation (48)	Large group	Team
Graphical Communication (48)	Small group	Small group

Table 1

ties in IT and related areas in three target areas. It shows significant improvement in some areas but not so good in other areas. The performance was averaged for the cohorts in the group. Figure 2 shows relative performance of students in the target areas on a graded level. The assessment in each target area was based on learning outcome defined for the grade level and utilized tests, projects, quizzes and assignments. The approaches used in different components of the project were analyzed to evaluate their impact in improving participants' learning and comprehension of IT and their skills in applying the subject matter. The methods focused on large and small group instruction, hands-on laboratory experimentation in an individual group setting, individual and team work in graphing, graphical communication and report, oral presentation using technology work, and use of packaged software. Table 1 show approaches that worked better in some of the project tasks.

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Reforming Education: The Pursuit of Learning through Authentic Inquiry in Mathematics, Science and Technology

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Challenge confronting educators

Across the world, governments are recognising the important role that science, mathematics and technology are playing to achieve healthy, safe and peaceful society. In Australia, the development of scientific, mathematical and technological literacy is a national priority for the education system. A number of major reports have implicated the quality of teaching, the relevance of the curriculum and teacher training as areas of major concern (Breakspere, 2003; Goodrum, Hackling & Rennie, 2001; Glenn, 2000; Miles, 2000; NSB, 1999). In essence, classroom teachers and policy makers are being encouraged to accommodate global perspectives, contemporary issues in the sciences and acknowledge the myriad of social-emotional problems confronting modern youth and provide more meaningful learning contexts.

However, the teaching situation in many classrooms is problematic. Contemporary learning theories acknowledge that learning has to occur in context where students engage actively in negotiating meaning around new experiences. Learning theorists argue that the most important source from which we gain understanding is first-hand experience in a social context. However, traditional schooling is dominated by models of teaching, which assume learning occurs through transmission of information. Students are forced to learn from secondary experience, in which information is selected, modified, packaged and presented to them by "expert" teachers. The adoption of these models are further reinforced by community attitudes that tend to see education in mathematics, science and technology as being training for specialised careers in technical fields, rather than part of the essential general preparation to be an informed citizen in the twenty-first century. Reforming classroom practices to achieve a better balance between first-hand and second-hand experience requires teachers to assume new supportive roles in the classroom and develop the appropriate pedagogical knowledge to support new forms of learning.

Examples of inquiry learning

In this paper we draw upon a number of studies in which students engage in original inquiry problems. It is argued that students build their understanding and investigative skills through active inquiry, connecting their previous knowledge with new ideas and evidence. We specifically report on examples from the early years of schooling and in middle school.

Mathematical investigations

Mathematical investigations have three key implications for teaching. First, they are extended problem explorations, which provide students with opportunities to engage in deep learning through the identification of a problem, collection of data, exploration of multiple strategies, communication of solutions, and reflection on the outcomes of the investigation. Second, due to their open-ended nature, teachers can capitalise on the use of investigations to provide opportunities for students with a range of mathematical abilities and interests. Additionally, teachers need to cater for the diversity of students by creating authentic opportunities for collaborative teamwork because individuals can contribute their specialised knowledge or skills to the task. For example, one student may undertake and record complex calculations within an investigation, whilst another student may complement the symbolic representations of these calculations with text and pictures. Third, investigations provide a context for students to apply their mathematical skills and to learn new skills. Hence teachers can determine whether students not only know how to do a procedure, such as addition, but can apply it. For example, in one investigation students erroneously calculated the number of sweets in a sealed container by adding the height of the container and its mass. Thus the teacher needed to realise that although the students could add, their result was meaningless in this context.

Scientific inquiry

Several approaches to inquiry based learning in science can be identified. These include structured, guided and open inquiry. In both structured and guided inquiry the teacher plays a significant role in both identifying and planning the problem. However, open inquiries foster opportunities for students to experience uncertainties, ambiguities and the social nature of scientific work and knowledge. Here, the teacher plays a very different role. In this study, the constraints, affordances and concerns that guide the role of the teacher are addressed. The study highlighted the importance of three main issues. First, the formation of a community of learners was developed which facilitated the higher ability children and also contributed to enhanced performances of lower ability children. Second, an open-ended inquiry approach afforded opportunities for high ability children to grapple with more sophisticated ideas and processes. Third, classroom discourse was structured to encourage the development of "scientific talk" for the children.

Through these complex investigations students develop in context a range of key scientific and mathematical processes and skills such as problem finding, problem posing, constructing hypotheses, explaining, justifying, predicting, and representing, together with quantifying, coordinating, and organising data. Students become mathematically literate by generating and interpreting information that is represented in multiple forms such as diagrams, charts, tables, and graphs. They become scientifically literate by engaging in hypothesis testing and evaluation of evidence and they become technologically literate through the use of tools relevant to information or data gathering. These processes and associated understandings are essential for effective participation in a knowledge-based society. They become technologically literate through the use of calculators, the internet, and various word processing, spreadsheeting and presentation technologies.

Implications

The implications of this research impact directly on attempts to reform the teaching of science, mathematics and technology to acknowledge contemporary learning theory and to accommodate the burgeoning and changing knowledge base necessary for competence in the sciences. However, there are significant challenges. Curriculum innovations have historically failed to influence teaching and learning practices due, in part, to teachers' scarce opportunities to learn new content and improve their practice. Inquiry approaches to learning assume that teachers are well prepared to engage in inquiry themselves a position that is challengeable given the preservice educational courses most have experienced. Teachers on the whole have had limited experiences in scientific research or opportunities to generate knowledge themselves through inquiry.

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Tamil Mathematical Manuscripts and the Possibility of a Social History of Mathematics Education in India

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Objectives and significance of the study

In a country like India, where usually history of mathematics has largely been confined to the task of unearthing a 'glorious past', based on a corpus of written sources, highly restricted in terms of circulation, how different could be similar knowledge traditions in regional contexts?

In this paper, I intend to share certain methodological issues, which I encountered in my attempt to write a social history of math education in the Tamil speaking area of south India. As part of this attempt, I encountered a corpus of Tamil manuscripts on mathematics. These manuscripts have not yet drawn the attention of historians of any kind except for a group of Tamil enthusiasts who have published certain editions of these texts, more as a tribute to their language than to subject these texts to a critical enquiry guided by any disciplinary interest. The primary objective of this paper is to reconstruct a history for one such set of manuscripts in Tamil. Encuvati, Ponnilakkam and Nellilakkam are part of the corpus. These manuscripts have explicit pedagogic connotations in their organizational structure. The idea then is to relate these manuscripts to their institutional roles, in what were called the 'Tinnai' schools, the elementary schools of south India in the early modern period.

Research design and procedure

There are several versions of these manuscripts. Ideally, the foremost job for a historian would be to collate available texts to provide a critical frame for historical analysis. In the absence of such an attempt, for the purposes of this paper, I have chosen a printed edition of Encuvati, Ponnilakkam and Nellilakkam, published by one of the early Tamil publishers in the early part of the nineteenth century, which was in turn stored in the India House Collection. The initial task was to decipher the notational system in order to recognize the logic of organization of the texts. The entire text had to be translated in a form that would be useful both for dissemination as well as to enable a process of recovering the pedagogic context, in which such a text could have been used. It required much effort to look for the use of the numerical practices, as recorded in these texts, in other forms of past records. Inscriptions and palm leaves were identified that had extensively used the same system of arithmetical practice. The context for the manuscripts emerged gradually. Available information and sources were collected on educational institutions of Tamilakam, the Tamil speaking area of south India. The elementary schools, called the Tinnai schools came closer as the sites of transmission of arithmetic of the kind recorded in the manuscripts.

Three kinds of historical reconstruction were required.

a) History of the nature and extent of the 'Tinnai schools'

b) History of the texts in relation to the curriculum of the Tinnai schools

c) History of arithmetical practices in the non-institutional contexts of a village society

Findings

From a narrative that evolved out of such an exercise, I would like to share certain issues that emerged, which I thought are significant for subsequent attempts at a social history of mathematics education, a field still in its infancy in India.

The use of memory, not as a skill but as a distinct modality of learning arithmetic was conceived and practiced as evident in these texts. What could be the relationship between memoria and cognitive transformations involved in a history of arithmetic conceived, say, in terms of the movement from first order to higher order representations? I have contemplated ways to address this issue.

Organization of pedagogic manuals and modalities of learning can be conceived as integral to larger socio-historical processes. Use of language becomes central to such transmissions. The relationship that Tamil, as a language had with this body of arithmetical knowledge, whose orientation, in turn was thoroughly local socio-economic transactions, has the potential to offer valuable lessons.

Social distribution of competence and characterization of mathematical abilities are issues that, I think, are crucial in reconstructing a social history of mathematics in a country like India, which has deeply embedded social hierarchies. However, the history of mathematics, has always considered its task to be: identify levels of reflection or abstraction (otherwise characterized as meta-cognitive levels) that allow for further mathematical developments, and then, situate secondary issues related to processes of standardization and institutionalization. The idea of cognitive universality and social competence need to be situated in a historical context, in relation to the Encuvati manuscript corpus.

The problems that I faced in integrating these strategies will constitute the focus for my paper.

'Term' as a Bridge Concept between Algebra and Arithmetic

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Algebra has been an area of difficulty for most school students. Herscovics and Linchevski (1994) have pointed to the 'cognitive gap' between arithmetic and algebra. Researchers have attributed students' difficulties in algebra to the lack of understanding of the letter/ variable (Kuchemann, 1981; Booth, 1984; MacGregor and Stacey, 1997) and algebraic expression. Another reason for students' difficulty is that they cannot easily grasp the process-product duality inherent in algebraic expressions, that is, the fact that the expression stands for a number as well as for instructions to perform operations on the number or letter (Sfard, 1991; Tall, 1999). Linchevski and Livneh (1999) have found connections in students' understanding of arithmetic and algebraic expressions as students tend to make the same kind of errors in both places. Various studies by researchers (Kieran, 1989, Chaiklin and Lesgold, 1984) have claimed that most students in the elementary grades are not aware of the underlying structure of arithmetic expressions. They do not understand for example, that 683 – 297 + 235 and 235 + 683 – 297 are equal without calculating.

Research in the area of teaching and learning of algebra has indicated the importance of understanding the structure of arithmetic expressions to make sense of algebraic expressions and their manipulation. However, recently Linchevski and Livneh (1999) have raised doubts about whether structure oriented arithmetic teaching is really appropriate as a preparation for algebra.

A study, being conducted at HBCSE, Mumbai, aims to look at the transition from arithmetic to algebra in beginning algebra students (class VI). The transition takes place in the context of a teaching intervention, focussing on the structure of arithmetic expressions, and thereby exploiting the structure sense in understanding and manipulating algebraic expressions. Three phases of the study have been conducted with students from nearby English and vernacular (Marathi) medium schools. The first phase was exploratory and aimed at developing instructional material. In the second phase, a two-group design was formulated with one group receiving algebra instruction with instruction in arithmetic and the other group receiving algebra instruction without arithmetic. In the third phase of the study, a single group design was used with two groups of students studying in English medium and one group of Marathi medium students. There was no control group with all the groups being subjected to the intervention. Pre and post-tests were given to see the improvement in performance in each of the phases.

During this study, the concept of *term* has been identified as crucial for understanding the structure of expressions as well as for making the transition to algebra. Term is a number with the + or – sign preceding it, attached to it. For example, the terms in the expression 12 + 4 – 5 are +12, +4 and –5. In the traditional textbooks, terms are introduced in the context of algebra in class VI, and like and unlike terms are subsequently defined, leading to the rules for manipulating and simplifying algebraic expressions. The concept of term is neither connected to any other concept like the concept of equality nor given any meaning like +4 is '4 more' and –5 is '5 less'. The study shows that the idea of term is very powerful. It becomes impoverished by restricting its use to merely introducing rules of syntactic manipulation. In this paper, we discuss contexts where the concept can be of help to students not only in perceiving the structure of arithmetic expressions but also in seeing the parallels between arithmetic and algebraic expressions.

In the instructional sequence used for the teaching study, students first learnt to parse arithmetic expressions correctly using terms. A distinction was made between simple terms like +2 or –3 and complex product terms like +3×5. In the first phase, the rules of order of operations and the idea of terms were kept distinct, whereas in the later phases they were combined to give a more unifying approach as well as to give meaning to the rules of order of operations. Students are usually taught the convention of order of operations through rules such as 'do multiplication before addition and subtraction'. Now the focus was shifted from this procedural way of looking at an expression to a structural way by emphasizing that in order to evaluate an expression the terms in the expression must be combined (Subramaniam, 2004). Simple terms can be combined easily and a product term and a simple term cannot be combined unless the product term is converted into a simple term. While a pre-post comparison of students' performance indicated that they readily learnt this approach to evaluating expressions, the retention of these concepts over a period of time was low as is seen in their performance in the delayed post-test. It is possible that doing these exercises in the school in the traditional way interferes with the alternative way learnt for a very short period with no further reinforcement.

Students applied the idea of terms to (a) generate arithmetic expressions equal to a given expression (involving both simple and product terms) by rearranging terms and (b) to judge whether two expressions are equal. The former group of tasks were open-ended in the sense of having multiple correct answers. Students performed well in both groups of the tasks and achieved an accuracy of 60% to 70% in judging whether two expressions are equal. After working with arithmetic expressions, students could more easily write equivalent algebraic expressions (involving both product terms and simple terms) by rearranging the terms so that like terms are together, which is the key step for simplification. Effort was made to minimise the occurrence of conjoining in algebraic expressions (writing $2x + 3 = 5x$) by reminding them of the rules of order of operations in arithmetic expressions. The students stated these reasons in classroom discussions and would point out the mistake done by their colleagues but this did not always translate to correct performance in the written tests. Still, the students who had undergone such instruction performed better than those who had not, with the frequency of conjoining in the former group being around 15% to 20% and for the later group being around 45%.

The data collected through video recordings, classroom observation, daily practice exercises and tests suggest that clear understanding about terms can enable the students to appreciate the structure of the expressions and also help them to make a transition to algebra from arithmetic.

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Teaching-Research and Design Experiment – Two Methodologies of Integrating Research and Classroom Practice

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Introduction

The presentation will review the Teaching-Research and the Design Experiment methodologies – two approaches to teaching and research, which, with the progress of reform in mathematics education, have acquired new importance and significance (Lesh, Kelly, 2000). Teaching - Research, the process of developing the craft of teaching through the adoption and assimilation of scientific methodology in classroom work, originates in the principles of Action Research and its developmental history has been documented by several authors (King, Lonnquist, 1992; Noffke, S. (1994)). It is credited with the increase of teachers' classroom awareness, significant increase of work motivation as well as the increase of student achievement and interest in the subject matter. It allows the teacher to view her/his classroom as the scientific laboratory focused on the improvement of the process of learning. Design Experiment methodology in education, on the other hand, has its origins in Vygotskian notion of the Teaching Experiment performed "to study mental changes under the effect of instruction", according to (Menchinskaya, 1967; Hunting, 1983). The "scientific status" of Design Science was delineated by (Simon, 1970), while the Design Experiment as a contemporary tool of educational research was formulated by (Brown, 1992) and (Collins, 1992). Both approaches, Teaching-Research and Design Experiment share important characteristics of contributing to building the bridge between the educational research and teaching practice. The extension of the NRC report, *How People Learn: Bridging Research and Practice* (1999), notes that the most effective attempts at integrating the theory and practice have taken the form of small groups of teachers engaged either in designing teaching experiments in collaboration with researchers or by individual teachers researching classroom practices on their own in their classrooms.

We examine the common features as well as the most important differences of both methodologies; we propose a new model of teaching-research formulated recently in the community colleges of CUNY in New York City (NYCity model), which integrates their differences (Czarnocha, 2002).

Two approaches to the integration between teaching practice and research

The document *How People Learn* (NRC, 1999), asserts that one of the fundamental difficulties in the progress of reform in mathematics and science education is the lack of integration between research and teaching. This shortcoming results not only in a time lag between theory and practice but also reinforces the widespread belief that researchers' endeavors are irrelevant to classroom practices (Brown 1992, Saul 1995). One of the central issues, which motivate the emergence of methodologies that attempt to bridge that gap is the complexity of the classroom learning process. For an educational researcher, according to (Brown, 1992), the prospect of leaving the artificial environment of the psychological laboratory and with the help of the Design Experiment to enter the rich, complex, and constantly changing environment of the classroom is an unusual and exhilarating opportunity to observe and to understand the psychology of pedagogical dynamics directly in vivo. On the other hand, the NCTM-2000 Standards asserts that the teaching of mathematics is a complex practice in that it "must balance purposeful, planned classroom lessons with the ongoing decision-making that inevitably occurs as teacher and students encounter unanticipated discoveries or difficulties that lead them to uncharted territory" (p.18). To navigate this terrain and manage its inherent dilemmas (Lampert 2001), the ideal standpoint is that of a teacher-researcher, a professional who investigates the teaching/learning processes in her/his own classroom and uses this knowledge for furthering instruction and for the navigation in the "uncharted territories.

Consequently, the challenge of integrating the research with practice is being approached along two complementary directions, from teaching to research through the development of the Teaching-Research methodologies and investigations in the classes of individual teachers-researchers, and from research to teaching through the import of the educational laboratory into classrooms of teachers who, in collaboration with researchers, participate in designed experiments.

Both of those promising approaches, however, are besieged by significant methodological challenges, each bringing forth a host of new set of questions to be answered. On the side of the Design Experiment methodology one needs to ask how to design the experimental situation, which at the same time is imbedded in the regular life of the classroom? What research questions can be formulated for such a set up? Who is to perform the teaching experiments? Similarly the Teaching-Research methodology has to solve a multitude of equally serious methodological problems: what is the ethics of Teaching-Research? What are the research questions that a teacher can ask? How trustworthy is the research performed in a single classroom? How to increase the validity of classroom results?

Their similarities and differences

There are two main methodological similarities between the approaches:

- both of them rely on the cyclical nature of classroom research, which allows repeatedly refining the instruction and deepening the theoretical understanding of the issue at hand. Significantly, the researchers generally start their design experiments with the theoretical point of view to be verified or assessed through the classroom teaching experiment (The Design-Based Collective, 2003; Asiala, 1996), while the Teacher-Researcher usually starts with the practice of instruction (Malara, 2002), its observation and redesign followed by the possible formulation of the theory.
- both approaches agree also that the "central goals of designing learning environments and developing theories…of learning are intertwined" (The Design Based Collective, 2003, p.5)

The methodologies differ significantly in the set of priorities through which the central goals are realized. Teaching-Research is primarily concerned with the improvement of instruction in the classroom, and it draws its theoretical hypotheses out of particular instances of that improvement. The Design Experiment emphasizes the creation and development of theories of learning as its primary goal, with the improvement of learning process in a particular classroom seen as the secondary goal (Cobb et al, 2003). Similarly the role of the teacher is significantly different in both methodologies. In Teaching-Research methodology, the teacher is the main investigative agent and he/she organizes the classroom activities to fit them into the established research questions (Jaworski, 1994); in the performance of the Design Experiment the teacher is at most the member of the research team, rarely its central methodological figure whose craft knowledge serves as the main spring for investigations.

The research questions asked by each approach differ equally significantly. On one hand (Cobb & Steffe, 1983) assert that the investigator's interest in the classroom always lies in "investigating *what a child might learn*". On the other hand, the interest of a Teacher-Researcher is to formulate ways and means to foster *what a child needs to learn* in order to reach a particular moment of discovery or to master a particular concept of the curriculum (Czarnocha, 1999). The research question here can be "what representations, and in what order should I use in Calculus so that my students fully understand the coordination between epsilon and N in mastering the definition of the limit of a sequence?". Since that process of understanding is understood by the contemporary theories of learning to take place within the autonomous cognitive structures of the student, the teacher-researcher must investigate the workings of these structures during a particular instructional sequence (Czarnocha, 1999). "Are my students more visual or verbal in terms of their cognitive processing, are they working in the process or object mode of thinking?" – could be the goal of classroom investigations.

Teaching-Research (NYCity model)

Hence, despite the integration of the educational researcher laboratory with the classroom, there are essential differences between the two methodologies, differences that still hark back to the theory/practice duality. These differences impact the interaction between the two approaches and can significantly lower their effectiveness by not utilizing the maximum of their implicit potential. In order to get the maximal effectiveness from both approaches, full integration of the two methodologies is the immediate task of educators in this domain. A new model of bi-directional Teaching-Research called NYCity model has been formulated recently in community colleges of CUNY (Czarnocha, 2002). The new model proposes an increase of validity and trustworthiness of classroom research through its coordination with modern cognitive and constructivist theories of learning. The process of coordination can proceed along two routes. A teacher-researcher can use a general theory of learning at the very beginning of the teaching-research process in the classroom, organize its practice in accordance with the suggestion of the theory or research and investigate its effectiveness using theory-based criteria (Baker, Czarnocha, 2002), or the teacher researcher can perform a classroom teaching experiment designed on the basis of practical craft knowledge and then seek an appropriate general theory to explicate the empirical results (Czarnocha and Prabhu 2001). This variety of possibilities of teaching-research points out to the inherent subtlety "particularly as it regards the management of the research activities in the classroom, as it requires the teacher's full immersion into the streams of classroom interaction, at first, and secondly his/her abstraction from such a stream in order to observe and control the classroom dynamics that arises" (Malara, Iaderosa, 1998).

In a similar vein, (Czarnocha, 1999), in his report about the discovery technique of teaching in a high school classroom, notes "the necessity to maintain a flexible flow of the course while employing the teaching experiment for the instructional purposes. This necessity is mandated by the dialectical interaction between the two aspects of the instructor's role: that of a teacher and that of a researcher. In order to facilitate the instructor's goal, the discovery of proportions, the researcher had to discover the elements of cognitive knowledge of the students relative to this concept. As these discoveries were often unexpected and contradicted teacher's suppositions, the teacher had to change his pedagogical goals and formulate new activities better adapted to students' cognitive tools. He had to ask new questions, which hopefully, through addressing newly discovered levels of understanding would bring students closer to their moment of discovery".

The presentation will contain excerpts from the interview with a teacher-researcher utilizing the methodology of TR/NYCity model while conducting teaching experiment into student understanding and mastery of the concept of the limit (Czarnocha, Prabhu, 2002). The excerpts will illustrate dynamics of bi-directional teaching-research and its impact upon the learning process.

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Diagrammatic Knowledge in Mathematics in the Information Age

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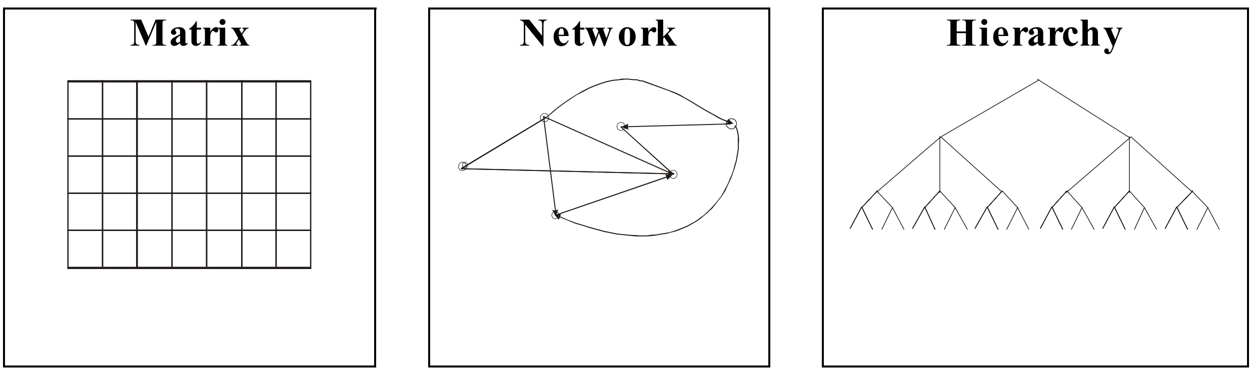
Mathematicians have long recognized the value of diagrams as cognitive tools and the use of diagrammatic representation has resulted in major mathematical breakthroughs, such as the Pythagorean discovery of irrational numbers. However, in the Information Age society, all citizens need to be able to create and interpret general purpose diagrams, such as the matrix, network, and hierarchy (Diezmann & English, 2001). Diagrams have three key cognitive advantages. First, diagrams facilitate the conceptualisation of the problem structure, which is a critical step towards a successful solution. Second, diagrams are an inference-making knowledge representation system that has the capacity for knowledge generation. Third, diagrams support visual reasoning, which is complementary to, but differs from, linguistic reasoning. However, students of all ages are reluctant to employ diagrams, experience difficulty using diagrams or lack the expertise to use diagrams effectively. Thus, students' use of diagrams can inhibit rather than facilitate their mathematical understanding and performance.

The ability to identify the properties of diagrams is a fundamental issue for diagrammatic research because the selection of an appropriate representation is a critical step in reasoning about information. As students encounter diagrammatic representations from their early primary years, it is essential to understand their knowledge of the properties of diagrams in order to promote mathematical learning and inform teaching practice. While diagrammatic knowledge and use have been studied intermittently over the past three decades, it is only recently that Novick (2001) has developed a cohesive framework of three general purpose diagrams (i.e., matrix, network, hierarchy) (see Figure 1) and their properties (e.g., were global structure, number of sets, item/link constraints, link type, linking relations and transversal).

This paper reports on an "in progress" longitudinal study of primary students' knowledge of the properties of diagrams using Novick's (2001) framework. Students' knowledge was explored through a series of scenario-based tasks that required them to (1) select a diagram that best suited the given problem information and to (2) justify their selection and (3) non-selection of particular diagrams. Scenario-based tasks are more appropriate for measuring knowledge of diagrammatic representation than problem-solving tasks because the former specifically elicit knowledge about representation, whereas the latter also involve reasoning.

The first sentence or two of the scenario tasks set up a cover story. The same broad scenario of "The Amusement Park" was used for all tasks to avoid students selecting their responses on the basis of the cover stories rather than the structural information. The next sentence or two focuses on a particular property of a diagram. The final sentence indicates that someone wants a diagram for a purpose relevant to the cover story. The students' task was to select the appropriate diagram from two labelled diagrams (matrix or network or hierarchy). In one of these diagrams, the property was represented, and in the other diagram the property was not represented. Only two (correct/incorrect)

Figure 1. Three general purpose diagrams.



spatially-oriented diagrams were presented for each scenario. Students were asked to justify their selection and also to explain why they did not select the remaining diagram. Examples of the tasks and the types of student responses will be presented on the poster. What was notable in the study was some students' reliance on the pictorial components of the diagram. For example, some students accepted or rejected a diagram on the basis of what could or could not physically fit on the diagram or the shape of spaces within the diagram. Thus, these students considered the diagrams as concrete representations of particular aspects of the story, rather than as abstract representations of the relationships between information.

The development of students' knowledge about diagrams was explored through interviews about their everyday (in school and out-of-school) experiences. The students' responses indicated that, as anticipated, there was limited attention to diagrams at school and no systematic effort to develop knowledge of diagrams. Generally, students' experiences with diagrams were *ad hoc* and one-off. Sometimes there was passing reference to particular diagrams in class or students encountered diagrams on their homework.

Outside school, students encountered diagrams in various forms, such as knockout sporting competitions represented on hierarchies. Some students were able to draw detailed reconstructions of these diagrams and talk about what they meant. Thus, these students had referents to which they could relate similar diagrams. The intent was to document these everyday situations that provide authentic contexts for interpreting diagrams and propose that these be embedded into the curriculum. However, there were also many students who had presumably seen the same information in common everyday situations as the diagram-aware students but had no recollection of these diagrams. This raises the question of what is it that makes something memorable or meaningful for some students but not for others?

In summary, this study contributes to our understanding of the way in which we think by extending knowledge of diagrammatic representation and cognition in mathematics. This has been achieved by investigating which diagrams and which properties are easier or harder for students. Students' explanations of their selections of particular diagrams to represent specific problem information provided insight into what information students perceived was represented on the diagrams and what they thought were the characteristics of diagrams. Knowledge of diagrams was further enhanced by a consideration of students' in-school and out-of-school experiences with diagrams. This exploration revealed that despite the heavy use of diagrams in print and electronic forms many students had scant experience or awareness of these important visual representations. Thus, the results of the study have broad applicability to all disciplines that use diagrams in print or electronic forms. If diagrams are to be used in learning, teaching or assessment, students must be diagram literate.

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Inquiry as a Tool and as a 'Way of Being' in Mathematics Teaching Development *

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Objectives and significance of the study

Research shows that mathematics teaching in Norway is not achieving the widespread mathematical know-how that society would like to see. The associated presentation from Bodil Kleve outlines recent such research and discusses teachers' classroom interpretations of the Norwegian mathematics curriculum, to explain the Norwegian position.

It is clear that mathematics teaching development is needed, and that this needs to involve teachers. We are moving away from traditional models of in-service development of teachers to a collaborative model based on "inquiry" as a theoretical perspective. With a substantial grant from the Norwegian Research Council (NFR) didacticians are building communities of inquiry with teachers in three levels:

1. Inquiry as a tool for mathematics learning in classrooms
2. Inquiry as a mode of teaching development
3. Inquiry as the basis of a research process to explore the contribution of inquiry communities to teaching development.

Our project is simultaneously a development and a research project. As didacticians work with teachers to develop inquiry communities we study the processes, practices, issues and outcomes of our activity. As teachers design activity for the classrooms, supported by didacticians, we explore the nature of the design process and its progress related to classroom activity. Our chief objective is to learn more about ways in which inquiry processes can contribute to the learning and teaching of mathematics and their development.

Underlying theoretical framework

We see inquiry both as a tool to promote learning and as a "way of being" in a learning environment. Collaboration in inquiry communities develops social processes in which questioning and exploration are central to knowing, and in which interactions take place with mutual respect that builds on the distributed knowing within a community (Cole & Engeström, 1993; Wells et al, 2001, Jaworski, 2003). Design of activity based on theoretical perspectives of collaborative inquiry will lead to innovative activity in classrooms which will be a source of reflection and study by teachers in developmental cycles which are the basis of study in the project (Jaworski, in press). We take the position that "Social science research has the potential to illuminate and clarify the practices we are studying as well as the possibility to be *incorporated into the very practices being investigated*." (Chaiklin, 1996, p. 394. Emphasis added.)

Research design and procedure

In our four year project which began in January 2004, data is collected from interactions between all participants in the project, including didacticians, teachers and students, in workshops at the college, teachers' meetings in school and in classrooms where students learn mathematics. In parallel we are undertaking a longitudinal study of students' mathematical understandings and attitudes and teachers' perspectives on learning and teaching.

A team of about 8 didacticians of mathematics from Agder University College, plus several doctoral students, are working in depth with 7 schools across the full age range, with a minimum of three teachers from each school as full participants in the project. Workshops at the college start the process of community building and developing inquiry as a way of being. Teacher groups in school, supported by didacticians, design innovative activity based on inquiry processes and collaborate on developing inquiry in their classrooms.

We are using quantitative and qualitative methodologies, including surveys, interviews, classroom observation and analysis of discourse. Multimedia methods of observation and analysis will contribute to findings.

The first 6 months of the project has involved recruitment of and early negotiations with schools, planning of workshops at the college, and consideration of our joint activity with teachers in schools. We, didacticians,

* This paper is linked to Bodil Kleve's paper. See p. 85.

have had to build first our own community. From diverse backgrounds, we worked collaboratively to design a research proposal based on the interests and expertise of all in our group. The proposal was one of seven to be funded in a special research programme of the NFR; however, the allocated funding was substantially less than our budget, so our programme had to be trimmed quite severely. On receiving funding our first step was to recruit doctoral students whose research would be part of the programme. Programme re-negotiation and early work with our doctoral students allowed us to address theoretical perspectives and to develop awareness of issues in putting theory into practice. Collaborative planning for workshops, some involving teachers, has led to addressing questions and dealing further with issues.

Findings

It is interesting to observe how methodology runs into findings, since our methodology develops along with activity in the project. For example, one of our objectives was that workshops should be a vehicle for building an inquiry community with teachers through which inquiry-based design of classroom activity could take place. It seemed fundamental that we should work together on mathematics in inquiry mode. The nature and style of mathematical tasks became therefore a focus of concern. What kinds of tasks or problems could initiate inquiry thinking and lead to ideas for classroom inquiry?

At the time of writing we have just held our first workshop using such tasks. We will report on outcomes as reflected in our data and analysis. Simultaneously we are analysing data from earlier meetings (audio and video recordings) to gain insights into our own processes (as didacticians and researchers) of community building and associated inquiry. We will report on and from this analysis.

To provide baseline information about students' mathematical competence, we have designed mathematical surveys to assess students in grades 4, 7, 9 and 11. Attitude surveys and interviews are currently being designed to enhance our baseline data. We are dealing currently with issues regarding the philosophical basis of such surveys and its relationships with the inquiry nature of our project.

Dealing with multiple data sources and approaches to data collection and analysis is proving challenging within the project. We will report further on such challenges.

By the time of the conference, we will have data from the early work in schools between teacher teams and supportive didacticians and will have begun analyses. We will report from this work. At that stage we shall not yet have undertaken a study of innovative activity in classrooms as a result of the design process. We must leave that to report at a subsequent meeting.

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Teachers' Implementation of a Curriculum Reform *

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Objectives and significance of the study

Reform 97 (R97) is the educational reform in Norway that took place in 1997. As part of the more wide-ranging Reform 97, which affected the whole of the compulsory education system, a new curriculum was implemented in August 1997. This curriculum or syllabus for grade 1-10 (age 6 to age 15) is referred to as L97 (Hagness, Veiteberg, Nasjonalt læremiddelsenter, & Kirke- utdannings- og forskningsdepartementet, 1999) from now on.

A research study (Alseth, Brekke, & Breiteig, 2003) suggests that the curriculum is not implemented as intended. Studies comparing pupils' performance on mathematical tasks before and after Reform 97 show that both in grade 7 and in grade 10 pupils perform generally lower in 2001 and 2002 than in 1995 and1994 respectively (Alseth et al., 2003; Kleve, 2003).

The curriculum describes different working methods in all subjects in general and in mathematics in particular. According to my interpretation of the curriculum, it encourages an investigative approach to teaching. It stresses that the pupils shall be active in the learning process. They shall be experimenting and exploring and through collaboration with each other acquire new knowledge and understanding.

In my research I have worked with 4 mathematics teachers to explore how they are interpreting the curriculum, both in terms of how they are thinking about it and expressing themselves in focus groups and interviews, and also in terms of what they actually do in the classroom. My research questions are:

1. How are teachers in their mathematics teaching practice responding to the L97's recommendations?

2. What kinds of interactions between the teacher and the student are observable in the mathematics classroom?

3. How are teachers' practices in the classroom related to their beliefs about teaching and learning mathematics and to their goals for students in the subject?

Underlying theoretical framework

The mathematical part of the curriculum, L97, reflects a constructivist view on learning and also a view based on socio-cultural theories. I see several principles which I interpret as reflecting a constructivist view on the teaching and learning of mathematics: pupils shall be encouraged to build up knowledge largely by themselves; they shall be active, enterprising and independent; they shall acquire new knowledge by exploring and experimenting. L97 encourages discussion and reflection, and emphasises how students' misconceptions can be ground for further learning. My interpretation is underpinned by Confrey (Confrey, 1990)who emphasises the fact that pupils themselves are supposed to construct their understanding through a process of reflection, Von Glasersfeld (Glasersfeld, 1985) who explains how teachers should be more interested in children's misconceptions and Noddings et al (Noddings, Davis, & Maher, 1990) who say that learning mathematics requires constructions and that mathematical activity in a mathematical community is a common thread in what a constructivist view implies.

Views based on socio-cultural theories are also reflected in the curriculum (L97, p. 167, 168). Collaboration and adult guidance are indicated. L97 says that pupils have developed mathematical concepts when they start school and the purposes of educational programmes are to develop these concepts. This is in accordance with Vygotsky (Vygotskij & Cole, 1978) who says that ignoring the fact that children's learning begins long before they attend school, is short-sighted. The use of tools is also emphasised in L97. Mediation through tools is essential in Vygotsky's socio-cultural theory. The tools in the Vygotskian mediation process are not limited to concretes. Language is also essential as a mediation tool. Lermann (Lermann, 2000) points to the analogy between physical tools and cultural tools and how they transform us internally.

Research design and procedure

In my study, I am focusing on teachers' interpretation of the L97 curriculum and on their implementation of

* This paper is linked to Barbara Jaworski's paper. See p. 83.

it. The relation between the two is an essential part of the study.

I am using research methods fitting largely into an ethnographic approach (Bryman, 2001). I have used focus groups interviews to get information about what teachers say about L97 and how they relate their teaching to what is said in the curriculum. I have observed four selected teachers for one lesson a week in 3 months, and have had conversations with them before and/or after the lessons. All of this has been audio taped, and parts of it are fully transcribed, from other parts I have written summaries. I have also information from the teachers obtained through questionnaires and self estimation forms.

Findings

So far, findings suggest that there are different attitudes to L97, different styles of teaching and thus different responses to L97. Very carefully I will indicate a Directive, a Leading, a Conceptual and an Exploring style of teaching. All four teachers have features of all styles of teaching, but to different degrees. One teacher, David, consciously and confidently carries out direct instruction. He interacts with the mathematics and poses his way of doing it over to the students. According to focus group interview this is what he believes in. Alfred leads his students towards a solution. He is concerned about his students' fragile thoughts and well being. Bent focuses on students' conceptual understanding and wants the students to understand the formulas. However he finds it hard and time consuming to carry out experimental teaching even this is what he says he believes in. Cecilie believes that students learn most by finding things out themselves and she carries out exploring activities and encourages students to find things out themselves.

Even though I experienced exploring activities during my classroom observation and also teachers wish to carry out such activities, I didn't experience that as a general working method. There are common features in all lessons I observed. They follow a traditional pattern; the teacher starts the lessons by explaining new material and/or reviewing the previous lesson, then pupils work on tasks on their own or in pairs while the teacher goes around. Specified skills are often in focus, and the entirety of the subject is rarely presented. However, as indicated and shown above, the nature of teaching from the board (the degree of students' participation) and of interactions between the teacher and the students, differ from classroom to classroom and will be subject to further analysis.

This also indicates that L97 is not implemented as intended and thus a need for further mathematics teaching development in Norway. In her associated presentation, Barbara Jaworski outlines how we now are moving away from traditional models of in-service development of teachers to a collaborative model based on inquiry as a theoretical perspective.

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Investigating Teachers' Pedagogical Beliefs about Mathematics, Science and Reading Literacy in the PISA Project

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The Programme for International Students Assessment (PISA) is based on a dynamic and forward-looking model of *lifelong learning* in which new *knowledge* and *skills* necessary for successful adaptation to a changing world are continuously acquired throughout life. PISA does assess students' knowledge, but it also examines their ability to reflect on the knowledge and experience and to apply that knowledge and experience to real world issues. The term *"literacy"* is used to encapsulate this broader conception of knowledge and skills. PISA covers the domains of reading, mathematical and scientific literacy (OECD, 2003).

The results of PISA show wide differences between countries in the knowledge and skills of 15-year-olds in literacy. Many factors contribute to variation in student performance. One of the important factors is teachers' *pedagogical beliefs* and *practices* about *authentic teaching* that *promote literacy*.

The purpose of the present study is to compare teachers' *pedagogical beliefs vs. PISA's* teaching targets. In particular, to investigate the question: Do mathematics, science and reading teachers differ in their *pedagogical beliefs* about teaching methods, as well as in their *practices* about planning, teaching and evaluating?

Method

Participants: Participants were 372 teachers from 165 high schools who participated in the PISA Israeli project. In each school three teachers were chosen, one in each of the three tested-subjects: Mathematics, science and reading.

Measurements: A 22-item pretest measured teachers' *pedagogical beliefs* and *practices*.

Teachers' pedagogical beliefs were measured by *conservative beliefs* (such as, advocating frontal method and homogeneous classes), *progressive beliefs* (such as, the importance of authentic teaching, providing opportunity to students' experience) and *teaching efficacy* (like, good teaching can overcome students' disadvantage).

Teachers' practices were measured by three components.

a. Considerations in planning: *Child-centered planning* (such as, children's ways of thinking) and *subject-matter-centered planning* (like, learning curricular).

b. Teaching methods: *Frontal teaching* (such as**,** the degree of using "blackboard teaching" and *New teaching* (like, overhead projector, computers).

Scoring: All the above variables range from 1 – low to 4 – high.

c. Evaluation: Teachers were asked to assign weights to each of the following consideration so that they add up to 100%: Test (students' ability and performance), Effort (student's learning investment), Need (student's need of encouragement in grade assignment).

Findings and Discussion

In general, as it appears in our findings, the teaching practices of Israeli high school teachers is a far cry from the ideal expected to fulfill the PISA's teaching targets. While the teachers express relatively *progressive* attitudes, in their practices they tend to stick to the known, more traditional methods in both classroom teaching and students' evaluation. It is hard to tell whether this is a result of entrenched, hard-to-change behavior, or an outcome of systemic pressures – to "cover material" and prepare students for the standardized final tests that limits teachers' ability to experiment and implement alternative teaching practices. While teachers of various subjects do not differ in their declared attitudes, it seems that teaching specialty is a factor in shaping their practices. Mathematical teachers appear as the most conservative among the three specialty groups in both their planning and class practices as well as in their grading practices. However, the science teachers and not the reading group appear as the most non-traditional practicing group. A plausible interpretation of these differences, lie in the contextual conditions that may shape practices of science teaching. Science teaching has gone through considerable transformation in recent decades: Syllabi was renewed to include more "relevant" topics, the "subject" is now being defined as interdisciplinary and taught as such in some schools, and systemic guidelines advocate practices that combine class teaching, laboratory sessions and out of class learning, all of which create an environment for more *"authentic"* teaching. If this interpretation holds, it has important educational and policy implications.

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The Teaching of Place Value – Cognitive Considerations

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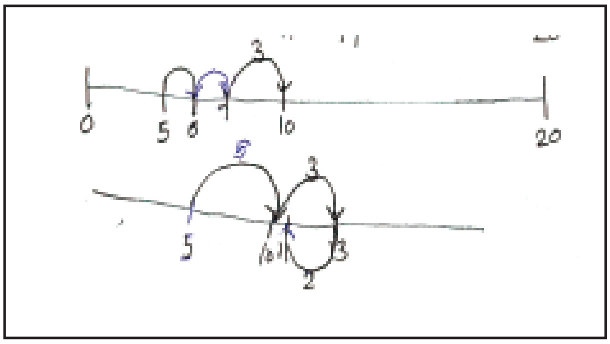
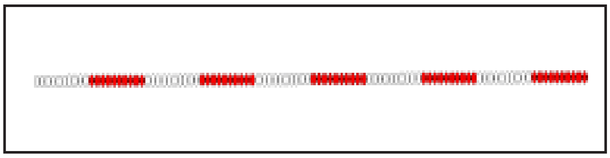
This paper considers the different approaches to the teaching of place value. It is argued that current practices involve a heavy emphasis on place value. Both mainstream and alternative approaches attempt to make children understand the meaning of the notational system for the writing of numbers. In mainstream cases, children are asked to write the numbers in columns marked out as units, tens and hundreds. In the alternative approaches prevalent in India, different concrete materials such as Dienes blocks and matchstick bundles are used to make children understand the *logic* behind the place-value system. In this sense, there is a commonality in both the approaches.

These methodologies assume that the learning of number as such is comparatively straightforward and that the real issue is that of understanding the *conceptual representation* of number or of number as the sum of products of powers of ten.



A different approach developed in the Netherlands delays the teaching of place value and focuses on the development of number sense. The activities chosen, such as counting on the ten-structured bead string (see figure) and the jumps on the empty number line keep the numbers whole without differentiating them on the basis of place value.



This method is strongly rooted in the conception of Freudenthal that there was more than one concept of number, which included counting number, numerosity number and measuring number. He argued very strongly that the numerosity number was 'mathematically insufficient', `mathematically unimportant' and `didactically insufficient' for the teaching of natural numbers (Freudenthal, 1973, pp. 179-194). He argued in favour of focusing on the counting number and the measuring number and specifically for the use of the number line. This advocacy of number line is related to the emphasis Freudenthal put on the constitution of the mental object by children (Freudenthal, 1983 p. x and pp. 28-33).

Theoretical aspects

I would argue that this RME (Realistic Mathematics Education) approach is significant both in terms of current theoretical advances in cognitive sciences *and* in terms of practical applications. In the framework of cognitive linguistics, mathematical concepts are seen as image schemas and conceptual metaphors. According to Lakoff and Nunez arithmetic is based on the four grounding metaphors of Object Collection, Object Construction, Measuring Stick and Motion Along a Path. (2000, pp. 50- 103) The logic of arithmetic is seen to emerge from the inferential logic of these four source domains by preserving the image-schema structure. The development of the mental object of the number line can be understood as a metaphorical blend in this framework.

In RME, activities with concrete materials are used not to embody the formal algorithmic operations but to facilitate domain-specific *level raising*. For example, in early arithmetic this involves, going from adding by counting to adding by structuring. The materials used are to be seen, not as devices for cognising the numbers that exist out there, but as functional extensions of the human body that literally lay the basis for new forms of cognitions. This can be understood in terms of Vygotsky's understanding of functional learning systems as mediational devices leading to changes in one's behaviour. Specifically on the question of arithmetic thinking, Vygotsky discussed how counting on the fingers served as a bridge between natural arithmetic (subitizing) and cultural arithmetic. Vygotsky argued, "the quantitative characteristic of any group of objects is perceived initially as one of the qualitative characteristics. ……….The matter changes as soon as man, in reacting to the quantitative aspect of any situation, resorts to his fingers as a tool to aid in carrying out the counting operation". (Vygotsky, 1997, p.52). Counting on the structured string and the use of the empty number line can be seen as the creation of new functional learning systems for the child, aiding to create a new mental object of number. This approach is also consistent with the studies on the relationship between procedural and conceptual competencies (Gelman and Meck, 1987).

In the bead string the colour cue functions as a neutral stimulus to organise counting. The colour cue gets recruited to solve the demands of the situation. This later gets internalised to form an understanding of the ten-based structure of the number system. The cognitive processes can be understood in terms of the 'methodology of double stimulation' that Vygotsky put forward (Vygotsky, 1999, p. 59).

The RME approach of mathematisation as a human activity also takes it beyond that of mere embodiment as seen from cognitive semantics. The importance accorded to the goal and affect in the designing of the activities brings it in consonance with the perspective of Activity Theory and the work of Vygotsky.

Practical Implications

The case for postponing the teaching of place value also comes from evidences that are emerging from countries outside the Netherlands. In a recent study from U.K., Ian Thompson has argued that place value should be seen to comprise of 'quantity value' and 'column value' and that the concept of 'quantity value' develops before that of 'column value' and pointed to the possible negative consequences of the excess emphasis on place value (Thompson, 2002, p. 10).

Analysis of Indian textbooks shows that most of the activities focus on embodying the conceptual representation in concrete materials for teaching of place-value. This emphasis on place-value goes to such an extent that children are taught numbers up to 9 and not up to 10 or up to 99 and not up to 100. The unnaturalness of teaching up to 9 when children are using the ten fingers of their hands to count is obvious.

A counting based, number line using method as in RME would differ very much from the approaches prevalent in India. Yet experience in the last four years shows that teachers very warmly welcome a teaching aid such as the structured bead string/ *ganitmala*. This can be understood in terms of the traditional rote practices in which the emphasis is on the chanting of numbers forward and backward as well as on various forms of skip counting. In the traditional practice any form of visual support is given only up to number ten. The development of number sense in the traditional practices can perhaps be understood in terms of the structuring implicit in the number names. Yet these practices can be considered to have the potential to blend with those for developing number sense using the empty number line as a new functional learning system.

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A study on Integration of Teaching Science and Mathematics

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Introduction

Owing to the phenomenal advancement of knowledge, especially in Science and Technology, the importance of Mathematics is immense today. The application of Science like Information Sciences and Information Technology., Bio-medical Engineering, Biotechnology are some of the leading pursuits in which role of Mathematics is indispensable.

Moreover, contemporary investigations on Science and mathematics education reveal that mathematics lessons are dry and lifeless in most cases because the problems of mathematics, are mostly artificial and complicated and not related to the realistic issues of science and technology. Is it possible to teach them together?

Objectives and significance of the study

The objectives of the present study are, thus, the following:

1) To mathematisation of technological ideas and heir understanding.

2) To disseminate science and technology education through teaching mathematics and

3) To redesign the curriculum of mathematics to bring it in line with the growth of the subject, growth of science and technology as well as the changing needs of the society.

Teaching science and mathematics separately has become extremely difficult due to enormous proliferation of content matter of each subject. Again separate treatment of teaching and learning inhibits global comprehensions of ideas and concepts of different disciplines. Integrated teaching of science and mathematics is likely to save our time and vigor in learning those subjects.

Integration of concepts of Mathematics and those of Science and Technology: Theoretical issues

Scientific and technological ideas are best understood when they are presented in mathematical ways. The mathematical form of conversion of matter into energy is the famous equation $e = mc^2$. This simple energy equation shows how a tremendous amount of energy is hidden in a small amount of matter. Mathematical forms of science are brief but the information contained in such forms is quite huge and vast.

Again, there is a reversible interrelationship among mathematisation physical reality, scientific theories, social needs and technology. The more we understand these reversibilities clearly, the more we will understand the theories of science and technology. Technology, in fact, is the applications of science related to industry and the needs of people. Science and technology can be expressed in mathematical ways. Mathematics can be utilized as 'the language for science and technology'. In order to understand the application of science related to man in a better way, we are to teach mathematical components of science and technology in classrooms in the periods of teaching science to the learners. In this case mathematical forms are to be explained through physical interpretations. In science books, also, mathematical forms with the variables of science & technology and their with the variables of science and technology and their physical interpretations are given. Sometimes students feel difficulty in understanding such mathematical treatment.

On the other hand in the course of teaching mathematical topics, relevant problems of science and technology can be presented as applications of mathematical concepts. For example, the problems related to alloys, mixture and compounds, preparation of medicines and cosmetics, etc. can be given in the exercises of ratio and proportion taught in mathematics. Relationships among flow of current, electrochemical equivalent weight, time and amount of metal deposited can be explained in teaching 'variation'. Similarly, Linear Function of mathematics can be explained utilizing the Hooke's Law. In the same way irrational function and Trigonometric function can be experimentally verified using a pendulum. Thus, we find that a large number of problems of physics, chemistry, life science, geology, geography, economics can be presented in teaching different concepts of mathematics in different classes.

In fact, problems of science and technology can be classified and can be given in different content areas of Arithmetic, Algebra and Geometry etc. of mathematics. They are placed in the exercises of appropriate contents of mathematics. As for example, the problems of speed, velocity, mass, weight etc. are included in unitary methods while composition of mixture, compounds and chemical formula are taught during the discussion of principles of ratio, proportion and percentages. It is kept in mind that the knowledge of appropriate scientific terms and principles of science is a prerequisite in understanding those problems through mathematics.

Relationship between Mathematical concepts and relevant applications of Science and Technology is depicted in the table below.

Research Design and procedure

In the project, experiments have been conducted to teach the subjects (i.e. mathematics and physical science and biology) separately and through integrated approach over the control and experimental groups of learners of class VIII. Three schools (each of rural, urban and semi-urban) are selected for conducting the project.

For teaching through integrated approach, in the curriculum of mathematics, the following application areas are interspersed: Archimedes principles, Newton's Law, principles of lift pump, vacuum pumps, laws relating to pulley, measurement of pollution, sugar or hemoglobin content in blood, composition of soil and bio-fertiliser, etc. The evaluation of two approaches of teaching has been made and statistical analysis showing the efficiency of the integrated method of teaching has been shown and explained.

Dissemination of science and technology ideas through teaching mathematics at class VIII grade is also tested through the use of 'comprehension test' in mathematics. In the 'comprehension Test' the concept of speed, friction, laws relating to pulley, composition of soil are given. After reading the passage twice and thrice, the learners are to answer the mathematical problems given at the end. To answer the problems, the students have to understand the principles of science and mathematics both. The theme of the passage are familiar to them and presented in a story-telling fashion. The passage and the test are designed properly keeping in view the ability levels of learners and their background knowledge about relevant science and technology ideas.

Mathematical concepts/ideas/contents	**Relevant application of science and technology**
Arithmetic	**Physics**
Mean, Ratio Proportion, Unitary method	Measurement of force, Pressure, velocity, Calorimetry, Current registration etc.
Algebra	**Life Sciences**
Formula, Surds & Indices, Equations	Seed germination, Growth of bacteria, Plant, photosynthesis etc.
Geometry & Mensuration	**Chemistry**
Triangle & quadrilateral properties, areas of square etc. Volumes of solid etc.	Relation between p.v.t.d. Electrolysis, Radioactivity Chemical & Electrochemical equivalent weight etc.
Statistical ideas	**Geo. Sciences**
Measures of central Tendencies & Variability, correlation etc.	Graphs, Longitude, Latitude, Aeronautical distances, Determination of time in different places
Modern ideas	**Agriculture & fisheries**
Sets, Elementary Calculus, flowcharts, computer language	Use of insecticides Fertilizer, Cost benefit, Horticulture & tree plantation

Findings

It is observed that experimental group has shown better performance. The differences of means of both groups of all the three schools under the project are found to be significant. It is evident from the opinion analysis that the learners will understand the solution of the problems which will help them in understanding the practical problems of industry, Commerce and business such understanding would facilitate them in their professional, vocational and day to day life situations.

The mathematical problems related to science and technology are to be given in abundance in the content of mathematics so that the integrated method of teaching may be more interesting and attractive.

Concluding remarks

In view of the above experiences and illustrations mathematical treatment of technological ideas may be interspersed in mathematical teaching for better comprehension of both mathematics and technology . At first, selection of appropriate problems and their respective placement in mathematical topics are necessary.

Such integrated approach, if judiciously planned and meticulously spelt out may lead to true comprehension and global understanding of both mathematical and scientific principles as well as application of principles, i.e. technological aspect in a global and total way.

Students' Use of Language and Symbols to Reason about Expressions

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Reasoning and explanation by students has been of interest to most mathematics and science educators and psychologists like Piaget. Reasons are used to justify propositions and involve the use of language and symbols (mathematics or otherwise). Researchers have explored the use of language and symbols (signs and drawings) by students in the process of reasoning (Robotti, 2002; Radford, 2001). Vygotsky has also considered language as a tool for the construction and management of thinking.

Traditional mathematics classrooms, which are mostly teacher directed, emphasize writing clear steps, using correct symbols, syntax, etc., and not thinking about these objects, identifying relationships between these objects and operation signs and giving reasons using language or symbols. A number of studies have pointed out students' inability to deal with symbolic expressions. Students can neither make sense of the structure of the expression nor consistently use rules to manipulate them successfully (Kieran, 1989; Chaiklin and Lesgold, 1984; Linchevski and Livneh, 1999; Liebenberg, Linchevski, Sasman and Olivier, 1999). In a study conducted at the Homi Bhabha Centre for Science Education, Mumbai we have tried to capitalize on students' intuitive understanding of mathematical symbols and expressions, where they use their own language as well as symbols to reason about expressions. This work is part of a larger study, which focuses on the transition from arithmetic to algebra (Subramaniam and Banerjee, 2004). It is a teaching intervention study, being conducted on sixth grade students (11 to 12 year olds) in three phases. In the 2nd and 3rd phase of the study, a batch learning in the local language Marathi was included. One of the goals of this study is to let students focus on the structural aspect of arithmetic expressions and to exploit their structural understanding in the learning of algebra. Through the instructional modules, students learn to see expressions as a number as well as a relation (for e.g., $3 + 2$ stands for a number which is 3 more than 2). The structural understanding of the expression emphasises the concept of 'term' as a structural element and the concept of 'equality' as a structural relation between expressions.

In this poster presentation we will discuss students' use of language and symbols as a tool to justify their responses in three kinds of tasks: (a) exercises on comparing expressions without calculation, (b) finding the value of an expression given the value of a related expression and (c) filling in the blank with a term to make two given expressions equal. These tasks were given to students to consolidate the idea of terms and to reinforce correct parsing of expressions. Students had to justify their answers for each of the these questions using language or symbols. Reasoning enabled students to make explicit their thinking about mathematical objects as well as compelled them to look for relationships among these objects. Students, in the beginning, find it easier to verbalise their justification using language. But gradually some students spontaneously start using symbols to explain their argument. Others may start using this strategy taking the cue from their peers or the teacher.

In the tasks on comparing two expressions without calculation there were three subtypes: (i) expressions with one term constant (e.g. 37 + 58, 36 + 58), (ii) expressions involving terms compensating each other completely, making them equal (e.g. 53 + 38, 54 + 37) or (iii) expressions with partially compensating terms (e.g. 53 + 38, 55 + 37). Similar subtypes were posed for expressions with negative terms. The performance in all the subtypes of tasks involving only positive terms was high for all groups of students (80% to 90%). For exercises with negative terms, there was a difference in the percentage of correct responses between the groups that had been exposed to integers, albeit in a different context (80% to 90%), and the groups not exposed to integers (60% and 80%). The number of students who justified their answers with reasons is around 50% to 70% depending upon the complexity of the subtype tasks.

In the tasks on finding the value of an expression given the value of a related expression, there were two subtypes. One of the subtypes involved arithmetic expressions (if 326 + 598 = 924, then 324 + 598 = ?) and the other involved algebraic expressions (if $y + 35 = 72$, then $y + 34 = ?$). 65 % of the students successfully found the value of the related expression in the subtype involving arithmetic expressions and 56% of the students could justify their answer by giving a reason. In the second subtype, involving algebraic expression, 52% of English medium and 68% of Marathi medium students found the value of the related expression. The percentages of students giving reasons for the second subtype is 26% for English medium and 52% for Marathi medium students.

In the task of filling in the blank by a term to make two expressions equal (35 + 29 = 35 + 27 ___), 45% of the English medium students and 77% of the Marathi medium students accomplished the task successfully. Around 20% of the English medium and 5% of the Marathi medium students wrote the sum of the expression at the left side or the right side or sum of all the numbers in the blank (For e.g. 35 + 39 = 35 + 27 + 64). Around 10% of the students wrote –2 in the blank, probably using '=' as a sign for association indicating that 27 is 2 less than 29.

In the above three tasks, students gave reasons to justify their answers using language or symbols depending upon the subtype. In the 'compare two expressions without calculation' task, most students used only language while reasoning for the simple tasks where the pair of expressions had one common term. For subtypes involving complete or partial compensation, students often used both language and symbols to justify their answer. Some students compared numbers and some compared terms; some students compared the value of the expressions as a whole. Some students found the difference of the differences between terms in expression-pairs with partially compensating terms and even wrote out their reasons using symbols as in this example: "$28 (+1) + 32 (-2) < 27 + 34$". For the question if $y + 34 = 72$ then $y + 34 = ?$, one of the responses was, "If you add 35 to y you get 72 therefore if you add 34 to y you will get 71". In the poster presentations, a variety of such responses will be described.

The responses to these tasks show that students have the ability to spontaneously use language to make sense of the expressions and transformations on them. Some of them could also subsequently use symbols to show the transformations on the expressions. Looking at the students' ability to use language and subsequent use of symbols by some students in the process of reasoning, we can hypothesize the transition from intuitive to language-based to symbolic reasoning as a way to make sense of symbolic expressions and syntactic transformations on them.

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Math Wars and the Epistemic Divide in Mathematics

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1. Problem

(a) Why do school (K-12) students find mathematics especially difficult?[1] (b) What is a good way to ameliorate these difficulties? (c) Would the new technology of computation *fundamentally* change the *content* of mathematics?

2. Earlier attempts

The "new" math curriculum of the 1960's and 1970's sought to align mathematics teaching with the formalist approach to mathematics, finalized in the 1930's. More recently, the reformed constructivist "new new math" curriculum, endorsed by the US Education Department in 1999, but rejected as "fuzzy math" and "no correct-answer math" by its opponents,[2] has sparked off a huge dispute called the "Math War".

3. Our analysis

Learning difficulties peculiar to mathematics are the root cause of this dispute, and this paper locates the root cause of these learning difficulties in an *epistemic schism* within mathematics. The quarrel about *what* and *how* mathematics should be taught reflects fundamentally divergent perceptions of what mathematics *is*—and that ought to be decided *not* by mathematical authority, but by recourse to history and philosophy.

4. Re-examination of history and philosophy of mathematics.

Two key principles: (a) History and philosophy go together: distorted history distorts the philosophy of the subject. (b) The learning process mirrors the historical evolution of a subject, in a "fast-forward" mode: learning difficulties reflect actual historical difficulties.

Detoxifying the current history of mathematics. What is the actual history? When state and church combine, history becomes an instrument of religious politics—as also happened for the last 1700 years. Hence, the "historical" claim: mathematics originated in "Greece" and was further developed mostly in Europe. This racist fantasy (Bernal, 1991) is based on papal *fatwas* ("Doctrine of Christian Discovery"), and excessively flimsy evidence. (Raju, forthcoming) Current philosophy of mathematics hence *defines* mathematics as something that imitates the "Greek" method of proof—as subsequently (unwittingly) aligned to the requirements of Christian rational theology by Russell, Hilbert et al. This definition is supported by the claim of universality—which is bogus, since proof varies with logic, which varies with culture (e.g. Buddhist and Jaina logic), and is not empirically certain (Raju, 2001; Raju, 1999). Hence, also, we must accept as legitimate variations in the notion of mathematical proof across cultures, as in the Indian notion of *pramāṇa*, which involves the empirical (and irrespective of Western taboos against the empirical in mathematics).

The multicultural origins of mathematics. Actually, Europe inherited not one but *two* streams of mathematics with distinct philosophical orientations: (i) an Egyptian – "Neoplatonic" mathematics that was spiritual, anti-empirical, proof-oriented, and explicitly religious, and (ii) an Indo-Arabic mathematics that was pro-em-

[1] Ignoring possible variations across cultures we will go with the readily available data.
[2] including Field medallists and Nobel prize winners, *Washington Post*, 18 Nov 1999.

pirical, and calculation-oriented, with practical objectives. Much mathematics taught at the K-12 level is of Indo-Arabic origin: (1) arithmetic, (2) algebra, (3) trigonometry, and (4) calculus. Europeans, however, failed to recognize the distinct epistemic settings of the two streams of mathematics, and sought to assimilate both under one "universal" mathematics. This led to the real math wars.

First math war: Arithmetic. The import of the algorismus (elementary arithmetic algorithms), from India to Europe, via Arabs and Florentine merchants, led to the first math war, lasting some 500 years, from Pope Sylvester II (d. 1003 CE) to the 16th c. CE victory of algorismus over abacus. Apart from zero (place value system), zeroing or discarding non-representables (*śūnya*) was a key problem.

Second math war: Calculus. Indian methods of proof and rounding led naturally to infinitesimal techniques ca. 1400 CE, when Aryabhata's finite differences were extended to infinite and "Taylor" series expansions for the sine, cosine, and arctangent functions, to calculate precise trigonometric values—imported into Europe by Mercator, Clavius, Stevin, etc. via the missionaries established in Cochin from 1500 CE, and since required for the European navigational problem and the (related) Gregorian calendar reform of 1582 (Raju, 2001). The Indian infinitesimal techniques were again incompatible with European ideas of "universal" mathematics, so that Cavalieri, Fermat, Pascal, Gregory, Newton, and Leibniz etc. in the 17th c. while reproducing exactly the Indian infinite series, tried to "prove" them in the "Euclidean" way—with complete lack of success as is clear from Berkeley's criticism, for example. This second math war over "infinitesimals" lasted some three centuries until Dedekind's semi-formalisation of real numbers in 1872.

Third math war: Computers. Like algorismus and calculus, computers have again greatly enhanced the ability to calculate for practical application, but in a way regarded as epistemologically insecure (Raju, 2001). Abacus has now gone to Kindergarten and calculus has descended to K-12: analogously, computer packages, like my CALCODE, can now be used to teach nonlinear ordinary differential equations to K-12 students.

Phylogeny is ontogeny. In a nutshell, European historical difficulties in assimilating mathematics-as-calculation all relate to its perceived epistemological insecurity. This "epistemological clash" arose from an unacceptable theology of mathematics-as-'Greek'-proof. Analogously, the formal justification for K-12 mathematics (via mathematical logic → axiomatic set theory → algebraic structures → number systems → mathematical analysis) is out of the reach of most K-12 students. Hence, on the present paradigm, K-12 students are condemned to learn mathematics in an epistemologically insecure way, reflecting exactly the European history of difficulties with imported mathematics.

Correction. The situation can be corrected by changing over to the notion of mathematical proof within which the relevant mathematics originated.

Prognosis. Computers will subversively transform mathematics as arithmetic and calculus did earlier. With concern boiling over the issue of calculators vs memorized algorithms, US math warriors have failed to notice that computer arithmetic uses (floating point) numbers that *must* disobey most of the formal mathematical "laws" about numbers, such as the associative law (Raju, 2001). Further, next generation "quantum" computer may negate the very logic naively assumed as "universal" in the present-day (Hilbertian) notion of formal mathematical proof!

5. Conclusions

(0) We need to reject racist history which has fantasized a monocultural origin for mathematics, and has built the philosophy of mathematics around this fantasy.

(a) The present-day learning difficulties of much K-12 mathematics reflect the real historical difficulties that Europe encountered in the last thousand years in forcibly trying to fit practical mathematics-as-calculation, imported from India via Arabs, into the theological paradigm of mathematics-as-proof.

(b) The right way to ameliorate learning difficulties in K-12 mathematics is, hence, to teach practical mathematics-as-calculation, with its non-"Euclidean" epistemology, as fundamentally different from aesthetic/-theo-logic-al mathematics-as-proof (Raju, 2004). Accepting the empirical in mathematical proof, would help teach K-12 mathematics in an epistemologically secure way.

(c) Computers make manifest the existence of non-representables in any practical mathematical calculation, forcing a shift away from the formal understanding of numbers. Future computer technology may also probably transform the understanding of logic.

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Developing Cognitive Flexibility

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To represent "content knowledge" in the textbook simple looking, stereotyped, abridged forms are used. These knowledge representations are treated as the "ideal and only correct one" by many teachers and learners. The way teachers learn the mathematics and the way they teach it to pupils lead them to believe that the mathematical knowledge is rigid and rule bound. Consequently for most of the learners, mathematics learning ends in remembering textbook representations. If learners are assisted to make textbook representations meaningful for themselves then mathematics learning may not be drudgery for many of them. It is not possible for any educator to evolve a constructivist-learning environment all of a sudden for helping learners of any level to change their attitude toward mathematics learning. As a teacher one has to make deliberate efforts to create learning experiences that may bring in change in the mathematical activities in the classroom.

Available research findings show that if learners are assisted to represent their thought processes and understanding, using "different contexts", "different media" and "different modes" the learning situation becomes complex and challenges learners to be active. The situations thus evolved forces learners to work in collaboration for making textbook learning meaningful. The learners while revisiting their previous learning are expected to liberate themselves from the way of understanding and create many ways of understanding mathematics. The cognitive flexibility theory is relevant in this respect as it makes specific recommendations about multiple approaches that range from multiple organizational schemes of subject matter for instruction to multiple representations to be organized, taught and procedures and knowledge represented in different ways. One of the available modes for helping learners to act flexibly with respect to mathematical concepts is cognitive apprenticeship. By using this mode it is possible to model the process for learners and coach them to become expert performers. The critical feature of this mode is that the teacher is not supposed to serve as effective or flawless model (with intention). It is assumed that there is no idealized path for teaching or learning. The learners in this situation are expected to experience authentic way of doing mathematics.

This paper is based on my experiences with student teachers. Our learners are student teachers aspiring to become mathematics educators. They equal 'understanding' with 'remembering procedures for getting correct answers to the exercises that are given in the textbook'. They expect pupils to use the writing procedure that is given or rather dictated to them. Though clear instructions are given in the textbook for learners and teachers that they should try to use all possible methods of getting answers to the exercises, most of them think it as needless work. Efforts are made to help them to get experiences in learning mathematics as well as learning to design constructivist-learning environment. I expected to get answers to the following questions.

How far does a constructivist-learning environment help student teachers to change their views about learning in general and mathematics learning in particular?

Do the cognitively flexible environment and the cognitive apprenticeship approach help them become epistemically motivated with respect to subject knowledge and metacognitive aspects of learning?

Teaching and learning activities evolved were mentally engaging and needed relaxed atmosphere. Many learning cycles with emphasis on cognitive flexibility with respect to different mathematical ideas were needed for making student teachers comfortable with cognitively flexible learning environment. Learners appear comfortable with logical inconsistencies but become uncomfortable with flexible learning activities in the beginning as they feel that these are very complicated. They argue that they are in a position to answer questions related to the logic, as they are graduates but it is not possible with pupils. This opinion is consistent with the opinion of many teacher educators. They forget the fact that learning takes place only when the situation challenges a person. My experience with school children is different. Most of the school children enjoy this type of learning environment. Only few learners worry about important questions. If learner is epistemically motivated then she or he might ask questions related to the knowledge, the way it is represented and its origin. Epistemically motivated learners are 'inquisitive' and 'curious' about every experience they encounter. For example they may be asking questions like how a particular way of representing different mathematical operations has evolved, how much time and effort a particular human culture required to evolve mathematical concepts, are there different number systems with different logic, etc. My efforts as teacher educator did not motivate student teachers to ask these types of questions.

This cognitive apprenticeship did help some student teachers to change their view about learning of mathematics and about mathematics as a subject to some extent. Now they don't restrict their learning and teaching to solving exercises given in the textbook. They are motivated to learn more about subject but they are not yet empowered to question the authority of the textbook knowledge and fail to transfer this learning skill to the learning of other concepts. For example they did not able to apply this learning for studying concept of division or other concepts of this type. Similarly they did not think along these lines with respect to learning geometry. It appears that learners need more time to get attuned with this kind of learning approach. Another aspect was evident through reflective exercises and their narratives about learning experiences. Student teachers did not think that they were learning mathematics and learning about teaching mathematics simultaneously. Their stance was to learn to teach and not learning to learn and teach. Some students mentioned the fact that they don't find any instance to ask epistemological questions. Major hurdle in developing cognitive flexibility is the attitude of teacher educators as well as student teachers. They think that we as teachers of mathematics are there to develop convergent thinking (certainty) and not divergent thinking (uncertainty). Thus getting final correct answer using a particular method or procedure is their sole aim of teaching mathematics.

What if Socrates uses Mathlets?

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Introduction

Any educational design would be beneficial as long as it could associate the technology and the teaching way of an old man who still guides us in many respects. On the one hand, we have Socrates (469-388 B.C.) the head of critical thought, brainstorming, creativity, in other words dialectic. On the other hand, we have java applets, the so called mathlets, which enable the unseen to be seen. It may seem as a conflict to search for linkages between the teaching method of an ancient philosopher and a new way of technology integration into mathematics education. However, this study aims to use Socratic questioning or in other words, the power of recollection for the students to analyze mathlets with indepth mathematical reasoning.

Theoretical framework

Socrates brought into attention the term "dialectic", or "question-answer". He referred to this method as the only admissible method of education, which is no matter of mere conjecture. According to Socrates, while all opinions are equally true, one opinion is better than the other and wise man is the one who by arguments causes good opinions to take the place of the bad ones, thus reforming the soul of the individual or the laws of a state by a process similar to that of a physician or the farmer.

Socrates believed that human beings had all the answers to all of the questions if only they knew how to ask the right question. In education, we have been using his ideas in so called Socratic Method and teachers were guiding students to find the answers within. Socratic Method has been used two folded both as a seminar to reach many students at once and as a one to one dialectic between teacher and the student.

Recently, mathlets gained importance due to their potential in their capability of giving students a sense of first hand experience of mathematical inquiry. A mathlet is a small scale interactive learning environment which is designed to address key ideas in science and mathematics (Confrey et al, 1998). They are compact, free to use, easy to find, and easy to use since they do not require any programming language knowledge.

Mathlets have the capability of introducing multiple, mostly dynamic representations of the same topic in mathematics. This ensures that students are able to see and observe the effect of different parameter changes and dynamic visualization. Socrates was a man who was surely ahead of his time and if he lived we believe that he would conjecture the possibility of usage of his ideas reflected on the image of the mathlets.

Research Design and Procedure

To begin with, derivative of a given function and tangent line will be taught by the teacher as usual to the third year high school students. A pretest, which is developed by the help of the web site where the java applet is positioned, will be administered (see Fig. 1). This web site includes a set of graphics, which is given in a 3×3 grid and each function below is the derivative of the function above. Students are required to identify with each column of the grid either the first and second derivatives of the function, the function whose derivative is the one given below or the integral function of the preceding function. This kind of activity enables students to see even the relationship between integral of a function and the derivative of a function. The graphics from this web page with the same idea of grids will establish the pretest questions.

Furthermore, students will be taken to the computer lab with their mathematics teacher. The first author of this paper is a teacher in a private school for 10 years. The subjects of the study will be drawn out of the original set of students of hers from her school. In the lab section the two applets presented in the appendices of

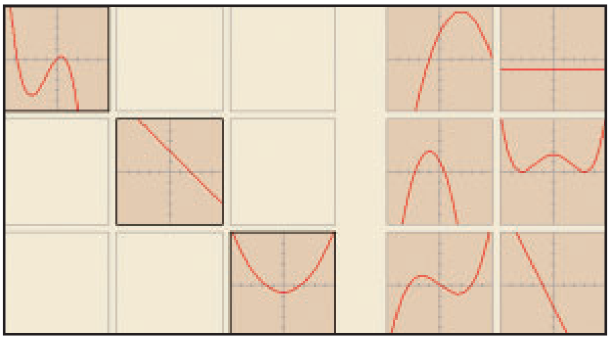

Figure 1. Pretest graphics

this paper; The Derivative Plotter and The Definition of the Derivative applets will be used. The teacher is preparing a lesson plan to accommodate these applets. She will use questioning in terms of Socratic dialogue and in the spirit of the Socratic seminars. Socrates believed that a teacher couldn't teach anything new to the students that they didn't know already. Hence, the questioning of the teacher will employ the idea of recollection.

As Richard (1993) mentioned once, the role of the skilled teacher/facilitator is to keep the "inquiry train on track," but, also, to allow the students to "travel to a viable destination" of their own design. This way of thinking clearly could be seen via Socrates himself "I shall only ask him, and not teach him, and he shall share the enquiry with me: and do you watch and see if you find me telling or explaining anything to him, instead of eliciting his opinion." within his conservations with Meno. Meno was a slave to whom Socrates used the first examples of a Socratic dialogue while teaching geometry to him. Our set of questions will be prepared keeping these example questions in view. This way, it is hoped that the students would manipulate java applets (mathlets) in a more enriching and productive manner and they could get the use these mathlets in a much productive way possible.

Finally, a parallel version of the pretest will be given to the students as a posttest. Then the students who will demonstrate unique ways of thinking with applets (those who got higher scores from the posttest and those who were identified as advanced mathematical thinkers by their teacher) will be interviewed to analyze their thinking with applets after the use of Socratic dialogue. In this interview protocol, unstructured interview protocol will be used to see and identify the possible effects of Socratic dialogue on students' thinking with applets. Here, students' self report will be adequate.

Findings and Analysis

It is conjectured that not only will the students take the responsibility for their own understanding but also they will master how to ask the right questions to get to the thoughtful answers. Their metacognitive abilities could be heightened and they could use this ability while learning other topics in mathematics.

Findings will be analyzed in terms of thinking processes and reasoning skills with both the topic at hand and also with the mathlets mentioned. A triangulation of the data from both quantitative gain scores and from the qualitative interview results will be carried out.

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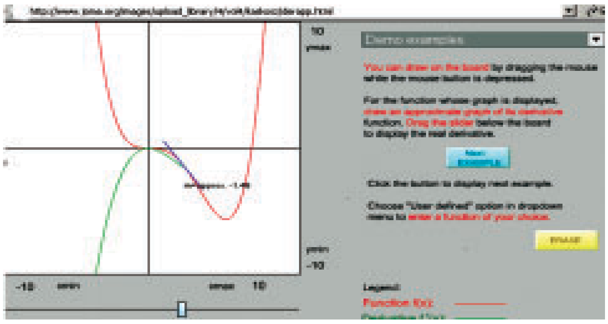
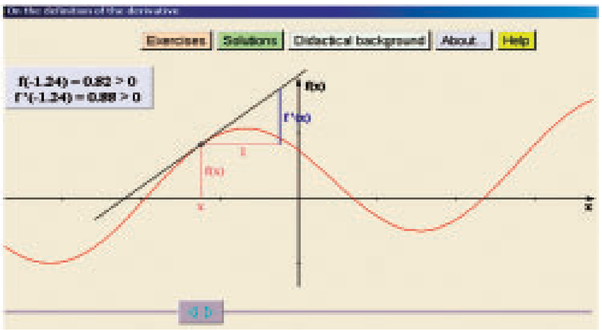
Appendix 1. Derivative Plotter



http://www.joma.org/images/upload_library/4/vol4/kaskosz/derapp.html

Appendix 2: On the definition of the derivative



http://www.univie.ac.at/future.media/moe/galerie/diff1/diff1.html

A View on Active Learning in Mathematics through Historical Context

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In recent times there was a consensus that students should learn through inquiry and through the construction of their own mathematics (Davis, 1991; Harel & Papert, 1990; NCTM, 1989). The same situation remains nowadays. The view of the learner has changed from that of a passive recipient of knowledge to that of an active constructor of knowledge. We take into account that current learning perspectives incorporate three important assumptions (Anthony, 1996):

- learning is a process of knowledge construction, not of knowledge recording or absorption;
- learning is knowledge-dependent; people use current knowledge to construct new knowledge;
- the learner is aware of the processes of cognition and can control and regulate them.

From a constructivist perspective it is easier for a student, under appropriate arrangement of teaching, to act as an architect, to reveal the truth and construct new knowledge, than to learn ready-made knowledge without understanding its origin, meaning and interrelations. In other words, "learning is a process of construction in which the students themselves have to be the primary actors" (von Glasersfeld, 1995).

At the same time, using history of mathematics is most naturally integrated in active learning processes. (By learning activities of students we mean their investigational work, problem solving, small group work, collaborative learning and experiential learning.) While solving a certain problem, every student has been proposed to investigate "mathematical situation" of it with his/her own priorities for further inquiry of that problem. Like Brown and Walter (1990), we consider "situation", an issue, which is a localized area of inquiry with features that can be taken as given or challenged and modified, but with its neighbourhood in historical-mathematical sense: when a certain problem was posed for the first time, who was the author, whether that author proved/solved a problem on his/her own, who of other mathematicians was interested in it, for what reasons, how long a problem was an unsolved one, etc (Yevdokimov, 2004).

We would like to consider the possibility of using principles of active learning in teaching mathematics through such historical context. The aim of our research was to show that students can learn effectively through appropriately designed historical environment. It is important to note that we did want neither stimulate students' using ICT support (e.g. dynamic geometry environment) nor restrict them in it. However, our choice was not taken by chance. Focusing students' attention on historical context of mathematical content we would like, on the one hand, to contribute that students' imagination would be absorbed in that time, when certain property was revealed or certain concept was proposed by mathematicians, from Ancient World to nowadays. On the other hand, we would like to develop students' abilities to analyze mathematical content from today's point of view and perceive evolutionary development of mathematical concepts and different properties throughout the centuries.

We proposed a flexible structure of units for active learning geometry supported with materials from the history of mathematics. Every unit consisted of three parts: preliminary, basic and advanced ones. In the preliminary part of every unit tasks were given in the usual form:

"Prove the following property for mathematical object X".

In the basic part of every unit most of the tasks were given in the inquiry form:

"What are the properties for mathematical object Y"?

And in the advanced part of every unit most of the tasks were given in the generalised inquiry form:

"Find properties of something" (without indication of a mathematical object, but concerning given "mathematical situation").

Flexibility of the units was provided with numerous links between tasks and materials of different units and easy transition from one unit to another without strict instruction in learning, i.e. unit-by unit. The main mission for teachers involved in research was their assisting students in discovering any property, which should be done by the students themselves.

The key question of students' inquiry work in all parts of the unit was the following: where, when and for what of mathematical objects a student would apply a certain mathematical property for proving and solving and whether it would be necessary to apply that property generally in that case. This question is connected with an *Active Fund of Knowledge of a Student* (AFKS) in the given area of mathematics. As AFKS we called student's understanding of definitions and properties for some mathematical objects of that domain and skills to use that knowledge (Yevdokimov, 2003).

We would like to emphasize that historical context in active learning of mathematics has invaluable importance. In our opinion, it is really an effective way – to learn and teach new mathematical content through historical context. Moreover, we found out that active learning of a certain area of mathematics through historical context enriches AFKS in the same area of mathematics and contributes to development of creative thinking of students.

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Transparent Objects and Processes in Learning Mathematics

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This paper examines the notion of *transparency* in learning and understanding mathematics. The notion of transparency may be associated with mathematical objects as well as thought processes. It carries two related meanings: Seeing-through and being visible. It has been addressed with respect to learning mathematics in a number of different contexts. In dealing with the roles and nature of mathematical examples, Mason & Pimm (1982) discuss the idea of a generic example, which basically is a specific example that conveys a more general case. That is, a generic example is *transparent* to a general case. The authors (ibid) suggest that often students fail to see in an example what the teacher had in mind. In particular, a generic example that is meant to demonstrate a general case or principle may be perceived by the students as a specific instance, overlooking its generality. When this is the situation, we consider the example to be non-transparent (or *opaque*) to the learner. Movshovitz-Hadar's (2002) approach to *transparent proofs* can be viewed as an extension of this kind of transparency. A transparent proof, according to Movshovitz-Hadar (ibid), is a proof of a particular case that is "small enough to serve as a concrete example, yet large enough to be considered a non-specific representative of the general case. One can see the general proof through it because nothing specific of the case enters the proof".

In the context of generating counter-examples Peled and Zaslavsky (1997) distinguish between counter-examples that only disprove a statement, and those that also reflect an explanatory feature regarding how it was generated and why it, in fact, refutes the statement. The latter can be seen as *transparent counter-examples*.

Another aspect of transparency in mathematics education is related to thought processes. More specifically, to the extent to which teachers' authentic mathematical thought processes are made transparent to the learners. Schoenfeld (1983) raises this point in the following excerpt:

"Part of the difficulty in teaching mathematical thinking skills is that we've gotten so good at them (especially when we teach elementary mathematics) that we don't have to think about them; we just do them, automatically. We know the right way to approach most of the problems that will come up in class. But the students don't, and simply showing them the right way doesn't help them avoid all the wrong approaches they might try themselves. For that reason we have to unravel some of our thinking, so that they can follow it." (ibid, p. 8).

In this sense, unraveling one's thinking is actually making it a *transparent process* to the learner.

The above discussion of the notion of transparency focuses on its meaning in terms of seeing-through. We also consider transparent objects and properties in terms of being visible. The proposed presentation will elaborate on the notion of transparency in mathematics education, and adopt it to examine a number of studies in which the extent to which an object or process is transparent plays a role in mathematical understanding.

Among the examples that will be presented are the following:

Transparent algorithms: There are several deep mathematical principles that are embedded in the basic arithmetic algorithms. Apprently, the algorithms are not equally transparent to each principle. For example, the long division algorithm, is highly transparent to the notion of periodicity, however, it is rather opaque to the place value principle. Empirical data that was collected indicate that these differences may account for some limtations and strengths in understanding this algorithm and carrying it out correctly (Zaslavsky, 2003).

Transparent definitions: In a study that aimed at identifying students' and teachers' conceptions of a mathematical definition, Shir and Zaslavsky (2002) found that the participants were reluctant to accept definitions of geometric figures based on their latent parts (e.g., a diagonal of a quadrilateral). This phenomenon is explained by the tendency to consider an element as part of a figure only if it is visible. That is, there is an expectation that the connection between parts of a figure and the figure itself needs to be transparent;

Transparent features: In sorting tasks that were given to mathematics teachers as group assignments, it was found that visible features of mathematrical objects were dominant in the sorting criteria, while more deep structured ones that were not transparent, were either not identified or were used at a later stage (Zaslavsky & Leikin, 2004).

Transparent problem solving processes: In an attempt to characterize a special learning environment that evolved within a project, the goal of which was to provide after-school mathematics tutorial sessions by engineers in an informal setting, some distinctive elements that enhanced students learning were identified (Zodik & Zaslavsky, 2004). One of the most salient characteristic that was identified in the engineer's tutoring was the way in which he made his thinking transparent to his students. He unraveled his thought processes by sharing with them each step, including his doubts and barriers in an apprenticeship like manner. He felt comfortable to turn to them for help when he felt stuck. This in return allowed them to become true contributing participants, leading to the emergence of a community engaging in collaborative problem solving activities.

To summarize, the claim that there is a strong connection between the extent to which an object or process are transparent to the learner and the understanding s/he develops, will be supported by findings from a number of studies.

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Cross-cultural Research in Learning Hurdles in Science and Mathematics

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Science and mathematics are taught as core subjects in school education all over the world. Taking into account recent scientific and technological advancements school curricula prescribed for these subjects have been modified considerably. Systematic efforts are being made in many countries to teach both these disciplines on a compulsory basis to all the students up to school leaving stage. This expectation is not easy to achieve if one wants to ensure that the teaching should go beyond scientific and mathematical literacy. School students face a variety of difficulties in comprehending and applying concepts in science and mathematics. A systematic research study to understand these difficulties and deliberate efforts to design appropriate remedial programme would enable us to teach these subjects effectively.

Homi Bhabha Centre for Science Education (HBCSE), a national centre of the Tata Institute of Fundamental Research (TIFR) for science and mathematics education, has been engaged in understanding learning hurdles faced by the first generation learners. Since its inception in 1974 HBCSE has undertaken projects both in urban as well as in rural areas to understand students' learning difficulties. Based on this understanding it has embarked on developing suitable methods/ materials to facilitate learning of science and mathematics. Among others things learning difficulties are found to arise out of socio-cultural deprivation, linguistic underdevelopment and lack of educational opportunities. Negative attitude of students toward these subjects supported by irrelevance of school content to daily lives add to the poor scholastic performance of students. When field-tested the remedial measures designed to overcome these hurdles were found to be quite effective. All the student-batches that underwent remedial instructional programme showed significant improvement in students' performance at the school leaving public examinations.

A programme was undertaken in rural secondary schools of the state of Maharashtra to test the utility of Remedial Instructional Strategy on a large scale. It was found that teacher training supported by follow-up activities and print material can equip the practising teacher to implement this strategy in a typical rural school. It remained to be seen if the strategy developed at HBCSE can be used in different cultural settings. This issue could be settled only if one finds that learning problems faced by the students from different cultures are qualitatively the same. It is with the purpose of understanding universal as well as culture specific problems across-cultural study was undertaken. It aimed at comparing learning difficulties faced by students from two different cultures.

The cross-cultural study was conducted taking samples form the schools in India and United Kingdom. Indian sample was chosen from schools in Mumbai and Vadodara. Both are industrial towns with metropolitan populations. The UK sample was chosen from schools in Milton Keynes, Luton and Bedford. All these towns are located in the central part of England and have multicultural population. In order to collect relevant data questionnaires were designed for students, their teachers and parents. A questionnaire for students sought their opinions about the areas of difficulty they face in studying science and mathematics, their attitudes towards these disciplines, the nature of help they get from their parents, their interests to pursue professions based on these disciplines, etc. A separate questionnaire was prepared for science and for mathematics teachers. These questionnaires attempted to know teachers' opinion regarding the underachievement of their students, nature of difficulties faced by students, their own viewpoints about the importance of these disciplines, plausible ways of improving the situation, etc. Similarly, the questionnaire for the parents sought their opinions about the importance of these disciplines in school education, their viewpoints about the roles these subjects play in the building students' personality, their use in day to day lives of their wards, etc.

The student-questionnaire was administered to students studying in grade 7 of the chosen schools. Their teachers were requested to complete the questionnaire meant for them. The students who took the questionnaire were requested to take parents' questionnaires home and get them filled from them. The analysis of the data reveals that the problem areas lie both in cognitive as well as in affective domains. As seen in the earlier studies of HBCSE the problems in concept formation arise mainly out of cultural deprivation, indifference towards these disciplines and lack of learning prerequisites. Students from different cultures display different beliefs and attitudes. Teachers' from different cultures also have different views on the underperformance of their students. Similarly, there is a significant difference in the ways parents from different cultures look at the scholastic performance of their wards. Nevertheless, there are a few common difficulties faced by students from both the cultures. These difficulties can be called as universal problems. One can thus design common methods and materials to overcome universal problems so that students' scholastic attainment in these disciplines is enhanced. Some hurdles are bound to be culture specific. The remedial instructional strategy has to take into account those differences and provide for suitable inputs to students, teachers and parents.

The cross cultural study discussed in the paper throws light on the universal as well as culture specific learning difficulties faced by the school students in mastering the disciplines of science and mathematics. They could certainly be overcome by modifying teacher-pupil interaction in the classroom. Such a change could be brought about through teacher training programmes. The study provides concrete guidelines for the in-service training of practising teachers. It also suggests inputs to be given to parents to utilise students' spare time fruitfully. The proposed presentation will outline the design of the study, method of data analysis and salient findings of the study along with their global implications. [The author wishes to acknowledge the help received from the colleagues at Centre for Curriculum and Teaching Studies (CATS), Open University, Milton Keynes, UK and Centre for Advanced Study in Education (CASE), University of Baroda, Vadodra, India in the development of the questionnaire, data collection and data analysis of the cross-cultural study.]

For a "Village" Involvement: Social Representations on Pluricultural School Community Actors

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According to a West-African proverb, it takes the involvement of a village to raise a child. The meaning of "village" refers to the necessity of the engagement of all members of the community around the school for the benefit of all children/students. In this paper, we explore what are the social representations of school actors in a R-7 primary school previously demarcated as "Coloured" school. This school is located in an urban area of the province of Eastern Cape in South Africa.

Objectives and significance of the Study

The study aims to identify the social representations about school community actors. For an efficient school we need to develop reciprocal understanding and a better communication among school actors in a perspective of intercultural education (Stonier, 1998; Sleeter & Grant, 1994).

Theoretical Framework

The notions of parental involvement and of social representations are crucial to this analysis. It seems, based on literature and experiences, that parents from diverse sociocultural and ethnic backgrounds interpret differently what **parental involvement** means. All parents seem to agree that it is their responsibility to provide their children with a supportive environment. However, there is disagreement about what constitutes such an environment and what family and school obligations are. Many parents believe that this unwanted participation can create "interference and disrespect. Some parents believe that teachers and administrators are fully capable of educating their children and that they have the sole responsibility" (Simich-Dudgeon, 1993:192) of doing that. In order to understand what parental involvement means, we suggest to look closer at the notion of **social representations**. According to Martin Sanchez (2000) and Jodelet (1991), representations are transmitted, socially shared and built through experiences, knowledge, and ways of thinking that can be "out there" or learned. Social representations aim to organize practices, actions, and ways of communicating (Rouquette, 1999; Doise, 1990). In summary, a social representation is related to "what" are the most important things (acceptable attitudes, opinions, and behaviours). It is also related to "how" an individual or a group is able to decode, think and comprehend what happens in the daily life in a specific social and cultural context, and "why" actions can be justified.

Research Design and Procedure

This qualitative approach implies the analysis of explicit and implicit content of multilayers of social representations (Deslauriers, 1991; L'…cuyer, 1988). Starting in January 2004, our data collection procedure consisted of two phases. The first phase began mid-January and ended mid-February. The purpose of this phase was to design a research framework, establishing a timeline, sharing our intentions with the school community, selecting participants, and clarifying the role of the research team members. The second phase, which includes questionnaires as well as conducting interviews and mathematics classroom observations, started in mid-February and continued through mid-April. During this phase, the principal, the deputy principal, seven teachers, six students, and four parents were involved. Questionnaires were given first to the principal and/or head of the department for intermediate phase who helped us to contact students, parents and teachers. The selection of our participants is based on their willingness to participate in the research, their capability to articulate their thoughts, and the diversity of their sociocultural background. Though the administrators of the school tried to fulfil our request, we were conscious about the fact that we did not select the student participants directly, which constitutes a limitation.

Even though all the students were instructed in English, we allowed them the choice to express their opinions in the language in which they felt more comfortable. All students chose their home language, except one boy who started in English and after a while asked us to switch to Afrikaans, his home language. Also, a parent switched back and forth during the interview. We were sensitive about the representativity of the participants in terms of gender (as many males as females) as well as in terms of socioeconomic status of the family. In order to preserve anonymity we referred to pseudonyms.

Upon the completion of the questionnaires, our data collection includes 30-60 minute interviews. All interviews were audiotaped, and a professional transcribed and translated from Afrikaans into English when it was necessary. The research team consulted school documents and the field notes that they used during classroom observations. Both data collection and data analysis occurred simultaneously during the course of the study. Constant comparative data analysis was used (Lincoln & Guba, 1994). Emerging categories were developed from participants. These categories describe the social representations on parental involvement.

Our model of explicit and implicit content analysis focuses on multilayers of social representations. It implies the description of characteristics of the participants' social representations about something they believe, imagine is true, and see as evident. Because our methodology is grounded in data collected from questionnaires and interviews, we let themes emerge from the participants' answers and we considered recurrent words that grounded theory studies individuals, groups, cultures, and society from an inside (emic) perspective. characteristics of the participants' social representations that emerged from what they believed, imagined was true, assumed without re-questioning, and saw as evident.

Findings

The findings of the study suggest that all parents have something to offer and they can help parents to develop self-esteem and confidence. Although parents from diverse backgrounds interpreted differently what parental involvement meant, all parents agreed that it is their responsibility to provide their children with a supportive environment. It was clear that parents wanted to be involved and educators thought that parent involvement was important. Parents, teachers and administrators of the school community pointed out the necessity of working together in order to afford all children the best education. In this sense, the school that we studied was exemplary. The school administration and staff believed the climate of their school was conducive to learning for children and educating the community.

Social representations on parental involvement may provide a wider and more inclusive definition for knowledge representation. It may include not only priorities of the school, but also priorities of the society where the people live and where the institutions serve them for the benefit of all children/students. This is an ongoing and emerging task that implies "togetherness". Passing from a perspective about family and school involvement to an understanding about this "togetherness" encourages us to shift towards the idea of a "village" involvement.

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Epistemological Stances Towards Knowledge in School Science and the Cultural Context of India

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Background

The declining student enrollment in sciences is a matter of serious concern for educators (Osborne, 2003). In attempts to remedy this problem, researchers have investigated and identified a list of factors that can influence positive attitudes towards school science which include religious affiliation, gender, personality, social structure, school, curriculum, teacher, classroom learning environment, etc (Schibeci, 1984; Simpson & Oliver, 1990; Myers & Fouts, 1992; Talton & Simpson, 1987). Studies in USA and Canada, for example, have shown that many students with deeply held religious values and beliefs have negative attitudes towards school science and experience difficulties in learning science or choosing a science career (e.g., Roth and Alexander, 1997; Ebbenshade, 1993). Ebbenshade (1993) found that of 121 high school students enrolled in a summer course on religion and science, 56% of boys and 43% of girls reported that they had "very strongly" or "often" considered a scientific career. Of these students, 28% stated that their religious faith would interfer with that choice.

Researchers have reported attitudinal differences towards science without investigating the underlying habits of mind. For example, does a belief in religious authority predict a propensity to dismiss scientific evidence? Does this belief promote negative attitudes towards school science? Is open-mindedness unique to science? To religion? Is it an aspect of both? Good (2001) argues that open-mindedness, the habit of mind so essential to scientific pursuits, always conflicts with religious faith in the authority of scriptures and religious leaders. Gauld (2003), on the other hand, argues that developing a respect for evidence, empirical or otherwise, is common to both "good" scientific and religious outlook. As yet, no study has examined what students of different orientations and habits of mind report as the social and psychological benefits of religion and school science. Better understanding of scientific and religious habits of mind might help to identify the sources of positive and negative attitudes towards religion and school science.

This study investigated relationship between religious orientation and attitudes towards religion and school science among high school students from a Himalayan region of India. The results of t-tests and multiple regressions reveal that the attitudes of these students were influenced by patterns of outlook common to both religious and scientific habits of mind. Self-fulfilling prophecy, cognitive need for explanation, and belief in authority are the patterns of outlook identified in this study. Each of the three thought patterns effected both positive and negative attitude towards religion and school science.

Method

Data source

Data was collected from eleventh and twelfth grade students (420 males and 614 females) in the predominately Hindu district of Chamba, Himachal Pradesh, India. More than 96% of respondents were from tribal (Gaddis, the nomadic shepherds of Chamba Valley) and non-tribal Hindu populations. Eighty percent of the responses were complete.

Survey

Surveys were used with high school students in India. This Likert-Scale survey measured the beliefs or habits of mind about the purpose, benefits, and authority of religion and school science. The survey included Hindi translations of items from Althauser's (1990) "ultimate-instrumental scale". These items measured religious orientation in terms of *ultimate* and *instrumental* reasons for religion. An *ultimate* religious orientation focuses on the truth or content of religious beliefs, experience (reasoning), and revelation. An *instrumental* religious orientation focuses on social and psychological benefits of religion.

The items borrowed from Althauser's scale measured the effect of ultimate and instrumental orientations on the perceived benefits of religion. Other items in the survey were modified from Altemeyer and Hunsberger (1992) to measure "unquestionable faith in a fundamental, basic, and inerrant religion" or religious authoritarianism. The survey also asked if religious practices (introducing scriptures and religious prayer in schools) should be part of school curriculum. The survey measured the affirmation of statements regarding the psychological and social benefits of religion and school science and the perceptions concerning the source of authority in school science.

Results

In this study, *self-fulfilling prophecy* was one of three thought patterns found common to both scientific and religious outlook. A majority of students affirmed positively the statements about the utilitarian value of the ideas and theories of religion and school science. However, a minority had less positive perceptions of inevitable benefits from both religion and school science.

Authoritarianism was the second thought pattern common to both scientific and religious outlook. Religious authoritarianism is characterized by an emphasis on the acceptance of dogma and rituals with unquestioning faith. Similarly, scientism is characterized by a belief in the unquestionable authority of scientists, science teachers, and science textbooks. Johnston notes that "scientism is a system of belief about the utility of scientific endeavors, a set of practices (the scientific method), prophets of old (the founding fathers of modern science), sacred places (the laboratory, the computer room), supreme loyalty and commitment to its adherents, the missionary zeal with which the proponents try to win others to win their faith in science" (Johnstone, 2004, pg. 13-14). An authoritarian outlook negatively influenced student perceptions of the benefits of religion and school science.

Cognitive need for explanation was the third common thought pattern to emerge in this study. This is the need to explain the "what" and "why" of daily experiences. Students, in this study, perceived both science and religion as beneficial in answering the need to explain natural events in the physical environment. Results show a strongly positive association between cognitive need for religious explanation and perceived benefits of school sciences.

It might seem that the strong religious orientations among the majority of students would correlate with positive support for religious practices in schools (teaching scriptures and holding religious prayer in schools). However, statistically there was no significant association in this study between an ultimate religious orientation and student support for religious practices in schools. The religious intent of students was found to be a separate dimension from support for holding prayer or introducing scriptures in schools. There was an association between an instrumental religious orientation and support for religious practices in school, but it was very weak. While the study was not designed to capture conflicts in the religious and scientific outlooks (e.g., between cognitive needs for scientific and religious explanations), an authoritarian habit of mind among some students was found to have a significant effect on their less positive perceptions of *both* religion and school science.

The results from this study indicate that positive and negative attitudes towards science and religion are more likely to be characteristics of general habits of mind, and are not limited to any domain of knowledge. Both scientism ('science as a form of religion') and 'religious authoritarianism' ('religion as a form of science') reflect such common habits of mind. Science educators have a major concern for the development of habits of mind that promote inquiry (e.g., Toulmin, Rieke, & Janik, 1979; Nagel, 1979). Future research could investigate the positive and negative influence of curriculum, teacher and classroom learning environment on specific thought patterns identified in this study.

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Primary Teachers' Views of Science and Culture Nexus

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A cultural perspective on science education views teaching as cultural transmission (Spindler, 1987; Wolcott, 1991). Science itself is viewed as a subculture of Western or Euro-American culture (Jegede, 1995; Maddock, 1981; Pickering, 1992; Ogawa, 1986; Pomeroy, 1994), and so "Western science" can also be called "*subculture of science*", because science tends to be a Western cultural icon of prestige, power, and progress. Its subculture permeates the culture of those who engage in it (Baker and Taylor, 1995; Hodson, 1993; Jegede and Okebukola, 1990, 1991; MacIvor, 1995; Ogawa, 1995; Pomeroy, 1994; Swift, 1992). This is known as acculturation and can threaten indigenous cultures, thereby causing Western science to be seen as a hegemonic icon of cultural imperialism (Battiste, 1986; Ermine, 1995; Maddock, 1981; Simonelli, 1994). Closely aligned with Western science is school science, whose main goal has been cultural transmission of both the subculture of science (Cobern, 1991; Layton et al., 1993; Maddock, 1981; Pomeroy, 1994) and the dominant culture of a country (Archibald, 1995; Krugly-Smolska, 1995; Stanley and Brickhouse, 1994). If science teachers are not aware of the cultural aspects of Western science, and are not aware of the differences between science and cultures, then they will not make good culture brokers and the science curriculum will be less accessible to their students. As a result, fewer students will succeed in science. There is the need, therefore, to find out what teachers have already understood about science and culture. This study is aimed to document primary science teachers' current views about culture and Western science, the interaction between culture and Western science and possible influence on participants learning and professional practice.

To carry out this investigation, thirty-four science teachers, registered for the part time teacher education programme, at the University of Benin (2002 contact session) were used. Sixteen (47.06%) of the participants were males while 18 or 52.94% were females. Candidates represented six ethnic groups in the southern part of Nigeria. A majority of the participants had taught for a period ranging from 5 to 20 years. Teachers all teach primary science but were admitted to read integrated science (a core subject at the primary and junior secondary levels of education in Nigeria) and computer science education. Students in addition had taken a one-semester course in integrated curriculum.

The instrument used for data collection was the 'Science and Culture Nexus Survey instrument originally developed by an international team O J. Jegede (Nigeria/Australia), G. Aikenhead (Canada), M. Ogunniyi (Nigeria/South Africa), and W. Cobern (United States). Section A is on bio-data and Section B consisted of five groups of questions: 'About science', 'Science and Culture', 'Science and Everyday Common Knowledge', 'Culture' and 'Teaching and Learning Science'. The items are linked in nature with 5 responses. The instrument was found to have alpha coefficient reliability of 0.64. The questionnaire was administered by this investigator during her normal class period with the students. The student teachers responded to the questionnaire and returned it within an hour. Data collected were analysed using mainly percentages.

Results

- Majority of teachers (more than 50%) agreed with the views of science expressed in the instrument except for two items (that technology does not need to have scientific bases and that technology can advance on its own know-how. This result is an indication of the teachers views of the importance of science for technological development of a Nation. However only few (11.8%) agreed that every occurrence in nature has a scientific explanation. This may be an indication of the teachers' strong view of culture.

- On science and culture, majority of the teachers disagreed with the views expressed on the instrument. Only 38.2% agreed that a person can integrate science with spirituality. This may be an indication that teachers view science and culture as separate existence. In addition 52.9% of the teachers agreed that science alienates one from his or her culture and 73.5% that science helps colonization. These are views of hegemonic icon of cultural imperialism (Baptiste, 1986; Ermine, 1995; Maddock, 1994). Interestingly, however, only 23.5% of the teachers were of the view that when students learn science they are likely to lose something valuable of their own culture. From these results, teachers are likely to be cultural brokers.

- On science and everyday common knowledge, majority of teachers disagreed with the views so expressed. For example they disagreed that scientific ideas are compatible with ideas within a community. However, majority agreed that scientific explanations and everyday common knowledge of natural phenomena should always be treated as one, and that it is easy to incorporate science into one's personal views of nature. Again these results may be an indication of the ease with which teachers may be able to help their students to cross borders.
- Majority of the teachers agreed with views expressed about culture. That is to say, culture is the lifestyle of the people and totality of their identity. It is transmited from generation to generation and probably with this result should not be abandoned for western science.
- Majority of teachers disagreed with views expressed on the instrument on teaching and learning science. They disagreed that the science concepts taught in school science have no meaningful use beyond passing examinations.
- Results also showed a significant interaction effect of gender and ethnicity on teachers' perception of science and culture. There was also a significant interaction effect of gender and teaching experience on teachers' perception of teaching and science learning.

These findings have implications for science teacher preparation and consequently for science and technological growth for non-Western countries with multicultural and ethnic backgrounds.

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Words and Worldviews: Production of Scientific Technical Terms in Tamil as a Cultural Reconfiguration and Domestication of Modern Science.

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The introduction of Modern Science into India during the middle Nineteenth Century, necessitated revision of the Tamil language so that it could effectively designate new reality domains. The issue of rendering this new knowledge form was not just a matter of mechanical translation from European languages into the 'vernacular', and the issue of rendering "science" in Tamil has be-en identified as a contentious issue. Hitherto studies on coining of technical terms in Tamil during the late colonial period were primarily focused on identifying 'correct' method for rendering Scientific Terms from English into Tamil or have tended to highlight the identity politics of those who favored 'pure' Tamil words and those who accepted Sanskrit words. In contrast, the 'reality domain' that these new words aspire to designate were usually considered non-problematic. As the identity politics surrounding the root words of the new terms being coined was problematized and accentuated, the studies were blind to the cultural politics of the metaphors about the reality ingrained inside these new words. This paper attempts to show, by way of critically narrating a case study, that the coining of the new terms was not just a matter of mechanical translation from English into the vernacular (in this case) Tamil, but 'translation' was a way of reconfiguring and domesticating the new knowledge.

The paper examines the contours of the development of the technical term to denote 'chemistry' in particular 'organic chemistry' in Tamil. While Rev. Fr. Fish Green, an American missionary advocated use of words in vogue amongst Tamil speakers for scientific technical terms, he discards the use of the word '*rasayanam*' arguing that the word comes to designate 'alchemy'; 'astrology' and all such superstitious ideas of the natives. As an alternative he coins a word '*chemistham*' (transliteration of 'chemistry') though many writers, especially native authors, used the word *rasayanam* to designate chemistry.

Rajagopalachari, a political activist and Tamil scholar coins a word '*Yakkai Rasayanam*' to denote 'organic chemistry'. The '*Yakkai*' has 'pure' Tamil root while *Rasayanam* is culled from Sanskrit but of common use among Tamil people. While justifying the use of the word '*yakkai*' to designate 'organic' it is possible to discern the deistic motive behind Rajagopalachari. *Yakkai* connotes 'organized' and alludes to 'vitalism' and 'chief organiser', that is God.

The word 'organic' designated various aspects in different historical periods. Its origin is in the word- Organ- a musical instrument. Latter the word organ was used to denote - body parts - such as eyes, hands and so on. From this usage the word 'organisms' was coined to denote things 'living and growing'. It was this sense in which the word 'organic' was dominantly used in the 18th Century. Interestingly Organic and Mechanical were congruent words till about the middle of the 20th century. Through 19th Century to about middle of 20th Century organic meant 'an object having parts which cooperate to produce a single useful result and that the separate parts having little or no value on their own'. Organic also had a connotation of either that 'which is *instrumentally planned* or that which is *naturally evolving*'.

Yet, C Rajagopalachari wishes to derive 'organic' of 'organic chemistry' forcefully from 'organized'. Was this the only option available to Rajagopalachari? The word 'organic' was translated into Tamil at different point of time variedly, but it is pertinent to note that never was 'organic' understood to be 'that is organized'; Organic rendered as *'Angkathhirkaduththa* [that which belongs to parts], *Karuvi pondra* [things that posses tools], *Urupolla* [that which has parts], *Indra* [Mechanical instrument]. Though the word 'organic' and 'organized' in Tamil had a same root in the past in the contemporary usage they had diverged sense. Organic is not one that is necessarily 'organized' in this sense.

True the study of organic chemistry was embedded in the ideology of 'Natural Theology' in Europe during the 1850s that would have obviously influenced Rajagopalachari. But soon there was a sea change in the understanding of structure of organic chemistry. By 1865 Kekule arrived at the structure of benzene. Development of spatial chemistry during the late 19th Century and early decades of 20th Century, manufacture of synthetic dyes, and emergence of chemical industry in early decades of 20th Century "established organic chemistry on a molecular basis out of vitalism." Clearly by the 1930s organic chemistry was not embedded in 'natural theology' and 'vitalism' was certainly out within the sciences. From the point of view of language, for Rajagopalachari there were many alternative options available to trace an appropriate 'root' word for 'organic' and to coin the word for 'Organic Chemistry' in Tamil. Alternatively he could very well have considered the word 'organic chemistry' as only a pronoun (just a name) and not a description, and coined a term to this branch of Chemistry, say as 'carbon chemistry'. Or he could have treated the word 'organic' as derived from the word 'organs' or 'organisms' [in the context of chemistry] and could have rendered it has 'chemistry of living things'. Or as was the contemporary usage of the term it could have be traced to ' those which are naturally evolving', but clearly Rajagopalachari chooses the interpretation 'that which is instrumentally planned' as the 'correct' meaning of the word 'organic' and alludes to argument of design; by categorizing it as a separate type of matter that possibly have hidden hand of 'creator' behind it.

The current technical term in usage *'Karima Vediyal'* (Carbon Chemistry) was suggested by Chennai Magahana Tamil Sangam in 1938 is exorcised of any reference to 'tradition' and as matter of fact is very secular. The term *Karima* means 'Carbon' and *Vediyal* means 'Chemistry'. However, the term *Vediyal* is a modern word coined from a root word *'Vedi'* meaning 'transmute'. The verb *'Vethithal'* implies transmutation of baser elements in *Siddha* tradition of 'alchemy'. The word *Vedi* also came to denote, I am told, 'Drug- esp drug used by Siddha school of medicine, derived not from plant sources but from chemical sources'. How did this secularization of coining of terms come about? Social historians posit that during 1930s there were broadly three well identified strands of ideological 'cultural politics' in Tamil Nadu. One group represented the traditional elite - largely dominated by Brahmins and consisting of elite from upper caste Hindu section were characterized by their sympathy towards 'tradition' - meaning Sanskrit traditions, and in politics advocating 'Pan Indian Nationalism'. Another group was the Tamil Vellala and non-Brahmin upper caste elite, who articulated 'Tamil identity politics' drawing inspiration from the Tamil past. Thirdly, there were the Left/self-respect movements, which not only questioned the 'past' but also 'invalidated' it. As the balance of power of the third group swelled in the public sphere during the 1940s; in the ensuing social upheaval, impact of the self-respect movement's rationalism and the left ideology geared the 'rediscovery programme' in a direction of taking it to secular plane away from the 'past tradition' or 'indigenous religion'. Rationalism was privileged in the re-discovery programme.

Language and the metaphors used in various disciplines of science generate social images, radically recast our perception of reality and suggest a possible relation and analogies. Analysis of metaphor illuminates the nature of changes in the meaning of theoretical terms, terms which are theory laden. Metaphors import social expectations into our representations of nature and by so doing they simultaneously serve to reify (or naturalize) cultural believes and practices. On the simpler and most obvious level, language gives us instruments of perception that conceptually magnify an effect; create- precisely those similarities and differences with which metaphors begin. Analyzing these debates and moves this paper argues that 'translation' was a way of reconfiguring and domesticating the new knowledge and evidently 'cultural lexicon of metaphors and images' of the recipient society are embedded in the technical terms coined.

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High Achievement in Mathematics and the Girl Child

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Introduction

Who are better in respect of achievement in mathematics? Boys or girls?

In fact, it has been found from the results of public examinations at the secondary and post secondary stages that the average performances of boys and girls in mathematics are more or less the same in different years. Some investigators, however, have found that boys are superior, while others have seen the superiority of girls. The mean differences between the performances of boys and girls in mathematics have been found, in many cases, not to be significant.

All the answers to the question posed above are of the following types : i) boys are better than girls, ii) girls are better than boys iii) there is no significant difference between the performances of boys and girls. Each of the above conclusions has it's own interpretations.

The problem

Let us now concentrate our attention to the performances of high achievers in mathematics. The following observations may be noted : i) In the list of renowned world mathematicians, the number of woman mathematicians is quite less. ii) In mathematics based subjects, (e.g. engineering and technology), the number of girls in less. iii) In the topper lists of H.S. Examination (Science Group), the number of girl children is less in comparison to that of boys. The above observations led to the conclusion that the performances of girls are always less than those of boys at the top level.

Objectives

Under the above context, the author intended to investigate the position of girls in respect of high achievement in mathematics. It is also aimed to collect and accumulate the reflections of different kinds of mathematics-people about such achievements of the girl child.

Experiences from the results of Achievement-cum-Diagnostic Test (ADTM)

Achievement-cum-Diagnostic test is organised by Centre for Pedagogical Studies in Mathematics, a reputed organisation, every year to ascertain the potentialities and diagnose the weakness of students ranging from class IV to class XII, since last fifteen years. Every year a large number of students participate in the test. The number of participant students ranges from 35 thousand to 55 thousand every year. About ten to fifteen students of each class (IV to XII), who top the list of students of each class are selected and rewarded. It has been found that about 35% of the participating students are girls. The number boys and girls in the toppers' list in different classes and in different years been found out and given in the Table 1. It may be pointed out that about 30% of the students come from urban area and the rest 70% of students are from semi urban and rural area.

Analysis

The table of toppers' list clearly shows that these girl children are less in number as compared to the boys. It is true that the total number of girl participants was about 35% to the total number of participating candidates. The proportion of number of boys and that of girls is 2:1 (approx.) but the proportion of the number of more-able boys and more-able girls is 9:1. The candidates of the test are both from rural, urban and semi-urban areas in proportion 2:1(approx.). The number of more able boys and girls has been found to be more in urban areas than that of the same in rural areas.

Totally speaking, it appears that, among the high-achievers, the number of girl children is less than that of boy children.

The present investigation can not claim that such generalisation is true in all cases. The results, however, indicate that, for some reason or the other, girl-children are not holding top-positions in greater numbers, particularly, in rural and disadvantaged areas.

Two case studies

It is necessary to investigate reasons for such low number of girl toppers and ascertain the causes of relatively poor achievement. First of all, it is necessary to know, what the students, teachers and administrators are thinking about this.

Year	The number of Toppers in different classes from IV - XII																				
	IV		V		VI		VII		VIII		IX		X		XI		XII		Total		Grand Total
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	
1996	13	4	12	0	12	4	12	3	17	0	13	0	12	0	3	0	2	0	96	11	107
1997	19	5	11	1	9	2	8	1	12	0	12	1	8	4	2	0	2	0	83	14	97
1998	14	1	11	3	11	1	7	1	10	0	9	0	9	1	3	0	2	1	76	8	83
1999	12	0	12	1	10	2	11	0	10	1	9	0	9	0	2	0	3	0	78	4	82
2000	10	1	10	2	11	1	11	1	11	3	11	0	5	1	2	0	2	0	75	9	84
2001	7	1	7	1	7	1	6	2	8	0	9	1	7	0	3	0	3	0	57	6	63
2002	12	0	9	3	9	1	8	2	10	2	15	1	9	0	8	0	3	0	83	9	95
2003	9	4	12	0	11	0	10	0	11	2	9	1	12	0	9	0	7	0	90	7	97
Total	96	16	84	11	80	12	73	10	89	8	87	4	71	6	32	0	24	1	63	68	704

Table 1: Number of toppers in Achievement-cum-Diagnostic Test in 1996 – 2003.

The following steps were undertaken.

i) An instant talk competition was arranged by the author, 12 students of class XI, and each one from twelve schools of which six were from Boys' and other six from girls' schools of Kolkata. Each student was asked to talk on the topic, " Why are the girls weak in mathematics?" The boys and girls gave relevant arguments in support of their answers. The responses revealed a lot of ideas in regard to so called weakness of girls in mathematics.

ii) A second step was taken. Twenty experts of whom ten are males and ten are females were selected. The experts were teacher-educators, teachers of mathematics from schools and colleges, and educational administrators. All of them were participants of a seminar on mathematics teaching organised by Centre for Pedagogical Studies in Mathematics. Each of the twenty participants were asked to state reasons on the issue 'Why is the number of girls less than that of boys among the high achievers in mathematics?' The group of experts took the issue enthusiastically and gave their opinions and comments regarding such achievement of girls.

Why is the number less?

The opinions expressed in the talk competition by the students, both boys and the girls were collected. Again the opinions and comments expressed by the experts were also taken into account. Finally a list was prepared, which according to the above respondents were reasons for low achievement of girls. These reasons were many, diverse and varied. It is to be noted that these reasons are not exhaustive. They, however, give a glimpse of what learners as well as experts think about such low achievement of girls.

Reasons for low achievement of the girl child

An analysis of the opinions of learners of experts revealed the following:

i) Most of the male experts opined that majority of the girl children are 'naturally' weak in mathematics and in mathematical reasoning, while most of the female experts did not agree to such a comment.

ii) The guardians do not usually encourage the study of mathematics for their daughters.

iii) The guardians normally think at the very beginning that the girl children are poor in mathematics.

iv) The girl children have lesser interest, attitude and attention in mathematical thinking.

v) In the matrimonial market the would-be-husbands and their parents prefer that the prospective bride should be conversant in fine arts (dance, music, drawing etc.) and the humanities, rather than in mathematics, science and engineering.

vi) In rural areas, the negligence of the guardians and the society of the girl child in their study of mathematics and science is highly discouraging.

vii) The girls have to do household work in addition to their study.

viii) The girls are prohibited from going outside and discussing the lessons with their boy friends, and male tutors and teachers.

ix) The experts agreed that there are many bright girl children also, who are learning mathematics with joy and enthusiasm in a better way than many of their boy classmates.

x) The expert group also opined that, given proper opportunity and encouragement, the girl child can excel in the same way as the boys.

xi) According to them it is encouraging that the girl children are doing better now as compared to earlier days.

xii) The number of girl students in a particular sample is less and hence the number of high achiever girls is less.

xiii) Boys are more efficient in 'hall manage' than the girls and hence boys get greater score in mathematics than girls.

Observations and their interpretations

First of all, it is to be admitted that the observation obtained from the results of ADTM for boys and girls are confined only to the population taken in the study. Thus, the observation that the number of girls is less than that of the girls in respect of high achievement in mathematics can not taken as a generalised conclusion. In fact, we often find many bright girl students who are shining in future as eminent mathematicians. But many facts, figures and findings as stated in our paper earlier, show that the number of girl-toppers is less than that of the boy-toppers in regard to achievement in mathematics.

Some opinions for this underachievement of girl child have been given above. It is to be carefully examined to what extent they can be accepted as valid reasons for under achievement of the girl child. It has been seen that 'bright' girl students in mathematics are less in rural areas than in urban areas.

It can thus be said that as socio-cultural conditions improve, the consciousness of gender equality also improves, and as such, the girl child gets greater motivation to do better.

Another significant finding is that such bright girl students are less in upper grades than in lower grades.

At lower secondary stages the boys and girls get, to some extent, equal educational opportunity. But, at upper secondary and higher secondary stages, the attention of guardians are focussed more on boys than girls. Again the parent also takes greater attention to see that their daughters take up humanities subjects rather than science subjects. Thus the issue of such under achievement ultimately reduces to social neglect of the girl child. In fact, in many cases, parents give more attention to boys, because they think that boys will get jobs and will help the family in future, so they select the boy child for study of science and mathematics, and provide maximum possible facilities to them. The whole atmosphere of learning mathematics for the girl child is in most cases not congenial for mathematical study. Again, the would-be-husbands and his family members prefer the bride to be conversant in fine arts, music, dance, cooking, humanities etc. rather than being engaged in the study of mathematics.

Let us consider the simulation in the classroom also in co-education classes, the teacher has in many cases the pre-occupied idea that boys are superior to girls, and so asks more questions to boys and lesser number of questions to the girls. The girls, on the other hand, being naturally shy and timid, do not intend to respond properly. The spontaneous intention of learning is thus thwarted. Being deprived of encouragement from parents, teachers, boy friends, family members and the society, the girl child herself starts thinking that she is inferior to the boy child in the study of higher mathematics.

It must, however be admitted that the above gloomy situation of learning mathematics is not always true. But, in most cases, the under-achievement of the girl child in mathematics, in case of occupying top-positions, is due to the negative attitude of gender-difference to the girl child by the school, family and the society.

The Role of Mathematics Education in Women Empowerment

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The importance of Mathematics as a tool for science and technology is continually increasing. While science and technology have become so pervasive, mathematics education has continued to dominate the school curriculum and remains a key subject area requirement in higher education and employment sector.

The hue and cry which follow the publication of mathematics results has become an annual ritual. The postmortems about the results eclipses a number of areas where female students have lagged behind. This has also impacted on courses and careers sought by women in the working world. They have attributed their failure to perform to expected standards to lack of sound background knowledge of mathematics. It is this realization that the skills learnt at school have had very little if any, bearing on what society needs in terms of productive citizens that prompted the research to look into problem areas in the teaching and learning of mathematics so as to equip students with the necessary skills needed on the market. In this regard, the gender imbalances in enrolment, achievement at school level, colleges and universities and the employment sector were also issues of concern. Our societies are becoming more and more technological with a mathematical bias, more attention being focused on attainment of mathematical competencies. Since Zimbabwe attained its independence in 1980, most women have taken indigenisation policy and affirmative action policy seriously. This has seen both the formal and informal sectors involved in the running of cooperatives and small business enterprises for which clear understanding and application of mathematical concepts and skills is required. This triggered the need for research into aspects pertaining to the role of mathematics education in assisting career choices undertaken by women. The argument is, to what extent does Mathematics education offer new challenges and opportunities for women advancement?

The 'O' and 'A' Level Mathematics syllabuses essentially spell out the national goal of laying a base for manpower training. That at tertiary level aimed at producing trained and skilled manpower for the country's economic growth were then looked at in light of the relationship between the level of mathematics education acquired and job opportunities through making a comparative study on the number of males and females undertaking mathematics in schools and colleges and in some of the mathematics-related occupations from both the formal and informal sectors.

Empowerment provides opportunities to increase knowledge and vocational skills for survival and also improves accessibility to more enterprising career paths for women.

Imbalances in enrolment, performance, subjects and subsequent employment in jobs that have a mathematical inclination underscored the need for intervention programs to bridge the gap while it revealed the need for a curriculum reform as a mechanism for improving the quality of education. Corresponding changes in assessment procedures are seen fit to accompany these reforms so as to ensure a holistic approach to learning. The research sought to provide a diagnostic tool from which to view other changes that were seen fit in the teaching, learning and assessment of Mathematics in the context of women empowerment.

This research was a descriptive survey whose target population was that of women in employment, undergoing skills-training and those still in high school. The research showed how these women are under-represented in mathematically related studies and careers. A stratified random sampling of high schools, colleges and the formal and informal employment sectors of the economy were used in the selection. Interview schedules and questionnaires were used in the collection of data. Both qualitative and quantitative cross validation exercises were conducted through observation schedules and archival records. It provided a base for further exploration of issues related to the design and delivery of mathematics education.

A trend analysis showing how enrolment and pass rates in mathematics have dwindled from 'O' Level through to mathematics-related occupations was established by way of a three-point moving averages. A correlational analysis of the career opportunities by gender was done starting from subject choices in the schools, tertiary institutions and subsequently in the employment sectors.

Even after independence in 1980 when the Government of Zimbabwe embarked on the process of reforming the inherited education system and redressing the disparities and inequalities, there is evidence that there was a significant change. As reflected by the statistics, Zimbabwean women continue to be under-represented in the modern sector, in high-level jobs and in higher education sciences despite improvements due to such legislation as the Equal pay Regulations Act of 1982, the Industrial Conciliation Act and the labor Relations Act of 1984. The analysis showed that overall female representation in the tertiary sector is still very low. Issues such as poor promotion prospects and lack of acknowledgement of women's concerns are quite consistent across colleges and universities.

In view of the above, the research tried to provide an overview of the position of women in tertiary institutions in Zimbabwe and went on to discuss why it is important to improve the present situation in mathematics education as a way of addressing gender inequalities. It also provided a forum for creating a women-friendly environment through systematically documenting and publicizing the areas women find problematic apart from trying to establish ways of implementing a series of equal opportunities and affirmative action activities in the classroom and employment sector. In addition the research was aimed at undertaking sensitization and social mobilization in support of the concerns of women, supporting the development and proper functioning of organizations that support women's concerns. By revealing the existing structural, organizational and institutional practices, the research targeted at how policies pertaining to these could accommodate the needs of women.

Mathematics and Gender in Ugandan Primary Schools: Influence on Teachers, Parents and Learners

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Problem, Objectives and Significance

In Uganda, gender disaggregated primary school performance data indicates that though mathematics is poorly performed relative to other subjects (Social Studies, English and Integrated Science), there is a significant gap between the performances of girls as compared to that of boys. This gap is not only evident during; teacher made and standardised examinations but also with the classroom participation. Basing on this observation, one would then wonder what the cause of this performance disparity is, since both girls and boys come from similar homes, sit in the same classrooms, are taught by the same teachers and are subjected to the same assessment. This rises an automatic question that of the stakeholders; parents, teachers and pupils, who is responsible for the observed gender disparities. The paper presents results of a study that was conceptualised with the overall aim of finding out the possible causes to the performance disparities among boys and girls in primary schools in Uganda. It was hoped that if careful note of the findings of this research was taken, the study would contribute to the bridging the performance gap between girls and boys in Ugandan primary schools.

Context And Underlying Assumptions About Gender And Mathematics In The Classroom

Research over the last two decades has shown that males and females have different classroom experiences because they approach learning differently and because teachers tend to treat them differently. Girls' achievement in mathematic during elementary grades is equal to boys' but decreases in the middle school (Callahan & Clements, 1984; Dossey et al., 1988). An analysis of math achievement of twelfth grade girls in 15 countries revealed that in all but three countries girls were less successful than boys (Hanna, Kundiger, & Larouche, 1990). That gender differences seem not to surface until age ten (Callahan & Clements, 1984; Dossey, Mulis, Lindquist, & Chambers, 1988) suggests that the decline of female achievement is the result of a strong pattern of socialization to mathematics success or failure rather than to gender differences in innate ability. As girls progress through school, they are less likely to continue their math education, either taking more rudimentary courses or dropping the subject altogether (Pallas & Alexander, 1983).

Study design and procedures

The study followed a cross-sectional survey design in which primary data was collected from; teachers, pupils, parents and the education policy makers. The respondents were randomly selected from primary schools within Kampala and wakiso districts while secondary data was collected from documents obtained from; schools, ministries of; Education and Sports (MoES) and that of Gender, labour and Social Development (MoGLSD), the Uganda National Examinations Board (UNEB) and the National Curriculum Development Centre (NCDC). To fit the study in within the context of the current debates, online interrogation of both published and unpublished reports was done. Data from both primary and secondary sources was analysed using qualitative and quantitative methods. Content analysis approach was employed for analysing the qualitative data using Nudist (N6) qualitative analysis software, while the quantitative analysis employed descriptive statistics computed using the Statistical Package for Social Scientists (SPSS).

Results, discussion and recommendations

Summary of results from this study indicated that attitudes of; parents, teachers and pupils themselves contribute to the gender perfomance gap between the female and male pupils in primary schools in Uganda. Other problems highlighted by this study are the unbalanced work burden at home, lack of motivation, confidence and the biased learning materials (see below).

Learners' Attitudes

Although about 100% of the females acknowledge Mathematics as useful, they did not work hard on the subject. Lack of interest, motivation and confidence made them view the subject as hard. Therefore females did not participate in Mathematics Clubs and did not do their Mathematics home works as much as did the males.

80.4% of the male pupils and 63.8% of female pupils believed that Mathematics was a subject for males. 33% of the females did Mathematics only after special encouragement.

Parents and the housework Burden at home

Many parents 54% of the parents attested that home based problems do interfere with girl's study at home. Problems included noise, household duties, visitors, video, lack of electricity, walking long distances to and from school, and children's failure to comprehend the work on their own. About 68% of the parents indicated that females were busier at home than males. Due to gender stereotyping these duties were normally the responsibilities of the female children. About 75% of the parents preferred male Mathematicians in the family and society.

The teachers reveal

Biased Teaching Materials

Teachers felt that maths textbooks were too difficult to be of much use in private study and that this adversely affect female who did not get as much external help as their counterpart boys. Teachers also reveal that the textbooks had a bias towards males, which could affect the females', drive towards Maths. Teachers thought this could be the reason why females hardly participated in class.

Females Lacked Confidence and Motivation in Mathematics

Most of the teachers (80%) believed that some pupils especially girls lacked confidence. The teachers estimate that about 75% of pupils most of them females, lacked motivation, consequently many females missed classes. They also believe that other factors include perception of Mathematics as difficult, regarding the subject as a reserve for males, shortage of females Mathematics teachers to act as models for females and hating Mathematics as a result of hatred for one topic.

Conclusions and Recommendations

In conclusion, pupils, teachers and parents suggested encouragement, explaining the importance of Mathematics, individual attention, regular roll-calls, putting pupils of various abilities to work together in teams, give more time for question, extra lessons and encouraging the pupils to practice problem solving. They also suggested the recruitment of more qualified teachers, on-the-job training of teachers, inspection by qualified senior teachers of Mathematics and the improvement of the teachers' conditions of service among others.

Gendered Communication in Technology Tasks: Glimpses of Group Interactions

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Significance and underlying theoretical framework

Communication, both oral and written is an essential component of the design and technology curriculum for school level being developed at HBCSE. Students record observations, describe investigations and communicate findings through oral presentations and written reports. Hence they need to be able to communicate effectively. Non-verbal communications (like gestures and expressions) are also important, especially for communication of feelings and attitudes.

Studies have shown that in a classroom setting, boys and girls have preferential ways of learning and expressing their knowledge and skills. Dale Spender (1980) highlights the gendering of language and how this has partitioned our world. Robin Lakoff (1973) observes that language use by children changes in different ways for boys and girls. 'Women's speech' which includes a large number of question tags, according to her, is the result of social interactions and reinforcements. The dynamics of group interactions and the social relations among boys and girls tend to be different (Thorne, 1993).

Like language, technology is gendered, and its know-how, design, fabrication and maintenance tend to be a male preserve (Cockburn and Ormrod, 1993; MacKenzie and Wajcman, 1999). The relative participation of women in technology and engineering courses is skewed; in India, women constitute only 17% of total enrollment in engineering and technology (Manpower Profile of India, 1999). Socio-cultural factors contribute to this situation (Kramarae, 1988). Kim Beat (1991) reports gender differentiated use of construction kits in nursery schools. Even five year old children have been seen to have definite views about what constitutes "men's work" and "women's work". Studies in secondary schools have shown that girls rarely engage in playing with tools and equipment, while boys not only have more experiences, but also a perceived expertise with equipment (Jones et al, 2000).

Objectives of the study

The Design and Technology project at HBCSE aims at development of gender inclusive technology tasks for middle school level. Three tasks were designed to engage students in measuring, planning, distributing work, designing, manipulating resources, making, communicating and evaluating.

Each task followed a pattern: students were set a real life problem, such as making a bag to carry their books in. They then explored the context, came up with alternative designs, communicated these and answered queries about the designs. The tasks were geared to develop students' oral and written communication skills through activities that required writing (poems, descriptions), drawing, technical drawings and procedural maps, listing materials and work distributions as well as presenting publicly, descriptions and evaluation of their own product and one made by others.

This paper focuses on qualitatively understanding social dimensions of resource and tool use in the task setting and the communication that occurred between and within group members during the technology trials.

Research design and procedure

Around 20-25 students from 3 schools participated in the tasks in separate batches. The students studying in class 6 and 7 were from 2 urban schools and a rural school which was a tribal residential school where the medium of instruction was Marathi. In the urban schools there was one Marathi and one English medium school. The 3 tasks were (i) bag making, (ii) making a model of a windmill to lift weights, and (iii) making a puppet and staging a puppet show. Each task was planned for about 15 hours, over a period of 5 days. Students formed groups of 3-4 members each. There were about 6 groups per school for each task; 4 single sex groups (2 boys' groups, 2 girls' groups) and 2 mixed-sex groups. Video and audio data was collected which included conversations and aspects of group dynamics. Each group maintained a file of their writings and drawings for the task. Researchers also kept a daily log of their observations.

Some findings

Students formed single sex groups spontaneously. They however, did not volunteer to form the mixed sex groups, and at times they had to be forced to be members of a mixed group. Many English and Marathi medium urban students were found to be confident and fluent oral communicators. Rural students took longer to complete written and oral activities, and their oral communication was more often inaudible. They also took time to open up even to the researchers. Special activities were planned with these students before embarking on the tasks to help build a rapport.

There were gender differences in the students' language use, often through explicit comments, such as, "*Yeh ladies lok ka cheez hai*"… ("This is ladies' stuff".) "It's nice that you have *ladki lok* (girls) in your group" (an all-boys group member to another group). Interestingly such statements were made by boys and corresponding references were not made by girls. Non-verbal communication, such as ignoring or refusing to look at / listen to another, also showed gendering. Girls in mixed-sex groups often found it difficult to be heard; a boy from the urban Marathi medium continued to ignore a girl from his group, who persistently tried to contribute to a discourse, even calling out to the boy "Aye, aye…..".

Other non-verbal communications were seen in acts of grabbing and trying to gain control over limited resources within a group. Sometimes fights broke out over this issue. Some groups were not willing to share common resources (sand from the garden became a commodity of contention). Sharing has various aspects. In some groups, the members who completed their work helped other members and groups. Communication space too can be shared; some groups gave a role to each member in public speaking, whereas in other groups this space was not shared.

Interactions within mixed-sex groups were often different from those within single sex groups. Work distribution was often clearly gendered. Girls took on, or were allocated by their group, activities of writing and drawing. On the other hand, activities such as, cutting the paper/cloth, hammering rivets, drilling and sometimes even sewing was done by boys. Girls were reluctant to take on the drilling activity even when urged by the researchers. There seemed to be a tacit assumption that the spheres of work of the two sexes are different.

In all the settings, some students were clearly the accepted leaders: the reasons were varied to include superior academic performance, age or physical build. In the urban setting, an academically bright girl was the accepted leader of an all-girls group; others including boys also evinced an interest in being part of her group. In a mixed group (tribal) two boys (big build, older) were the accepted leaders of the class.

The presentation, supplemented by video clippings will provide examples of gendered aspects of interactions and use of language and non-verbal cues while students performed a variety of activities in the three technology education tasks.

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Re-examining Gender Balance Education in Agricultural Science, Technology and Mathematics in Nigeria: An Overview

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Problem of the study

Despite policy formulation on equal and accessible education to both sexes, wide disparity exists between male and female education in Nigeria. Science education involves giving knowledge of scientific skills by teachers to learners through effective teaching learning process. Women in Nigeria have been found wanting in participating on different areas of science. Gender imbalance in Nigerian schools leads to inability of girls to study scientific and technical subjects thereby limiting the females' educational career and employment choices. This deprives the country at large of human capital that is highly valuable. (Odebode, 2001). This paper also examines how gender imbalance leads to absence of sexuality education, whereby young boys and girls and are not empowered to develop a positive sense of their own sexuality to acquire factual information to cope with life.

Objectives and significance of the study

This paper examines how culture inhibits the participation of women in Science, Technology and Mathematics and suggests strategies for women participation in Science. It also prescribes a policy of affirmative action to ensure that gender fairness and balance exist in all our actions.

Problems of gender-balanced instruction in school

One prominent problem of a gender balanced instruction in Science, Technology and Mathematics (STM) is the issue of sex stereotyping which is reflected in schools in textbooks, and lesson notes. The references involving the males in STM are discouraging.

Culture and education of any country determine the development of such a country and affect women participation in social, physical and psychologically oriented functions.

Culture also impedes gender-balance in schools, depresses the competence of some women when considering the sex-stereotyped roles at home, occupation pattern and the socialization pattern of a community.

In Nigeria, a father prefers to invest on boys' education than the girls. Girls are not motivated to aspire for Science, Technology and Mathematics-oriented discipline. Girls' education is perceived to lead to moral decadence in the northern part of Nigeria. They are therefore encouraged to marry early thereby preventing the opportunity for education. The birth of a female child is seen as a disappointment. They are second-rated in the Society.

Educated women are not regarded as good wives and they find it difficult to marry at the right time. This causes increase in the poverty and illiteracy levels in some occupations in Nigeria. In some cases, males refuse to marry females who involve themselves in some careers that are culturally termed "masculine." This however depresses the intellectual development, undermines the confidence and dampens the aspirations of the females. All these affect the attitude of the females or the girl child towards Science, Technology and Mathematics.

In some families, boys are counselled to be involved in some professions that will earn them more money and girls are counselled to offer courses that will make them to be good housekeepers. This negative attitude towards gender fairness should be discouraged and proper encouragement of gender balance education should be promoted. Girls should be allowed to be actively involved in the Science, Technology and Mathematics laboratories, workshops, seminars and classes to enhance their performances in schools.

The way forward

A major recommendation in this paper, is that Science, Technology and Mathematics education should be promoted in all schools (primary, secondary and tertiary) Agricultural science especially, should be given a high priority among other science subjects. Science Technology and Mathematics education should be accorded proper rights of organization, management and control by the school authority.

Enlightenment campaigns, reverse discriminatory policies, role modeling and activities encouraging girl-child or female participation in STM should be enhanced.

Non-governmental organizations, Ministry of education and subject associations should organize programmes on gender fairness issues to promote female participation in Science, Technology and Mathematics education. Women's association of Science, Technology and Mathematics should function actively in meeting its objectives on a very regular basis.

Incentives should be given to females in form of awards, scholarship in school to encourage female participation in Science, Technology and Mathematics education (Nsofor, 2001).

Moreover there must be programmes to popularize Science, Technology and Mathematics among girls from the nursery school level to the tertiary level.

Girls and women should strive to increase their scientific knowledge by reading periodicals, journals and relevant literature. Publishers and curriculum developers should discourage gender-biases in textbooks and curriculum materials.

Research institutions should develop programmes and projects to enhance women advancement and participation in Science, Technology and Mathematics education. Moreover, the men folk should learn to appreciate and respect the dignity and worth of women scientists and by willing to co-operate with, rather than discriminate against them at places of work.

Conclusion

This paper has attempted to re-examine gender-imbalance in Science, Technology and Mathematics education in Nigeria and reviewed the rights of women by considering gender balance in Science, Technology and Mathematics education.

Women must therefore be encouraged to respond positively to Science, Technology and Mathematics instructions and select careers in science-related disciplines to check imbalances. A favourable learning environment will be help to eliminate some problems militating against women in engaging in Science, Technology and Mathematics Education.

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Knowledge Organizers of Cell Biology

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As the scientific pursuit progresses, the number of technical terms in sciences is always on the rise. However, the use of knowledge organizers, more or less, remain constant. Knowledge organizers consist of (1) the types of concepts (Metatypes) used in knowledge (2) types of relations used to relate the concepts (Relation types) and (3) logical connectors and quantifiers used to express the knowledge.

Representing common sense knowledge using these minimal knowledge organizers is highly challenging, and often impossible since generalizations of common knowledge may not always work. However, much of scientific knowledge uses a small subset of our natural language since scientific language is highly conventional and formal. Our attempt is to represent already well organized scientific knowledge using Knowledge Representation (KR) methodology. The problem of representing knowledge of exact sciences like physics and mathematics is seemingly easier than not-so exact sciences like biology. The ontology of biological sciences is not as clear as other branches of science. In this work, we attempt to introduce our methodology for representing the knowledge of biological sciences. This exercise also helps us to explicate the structure of biological knowledge.

How can this methodology help us in science education? In science education, we expect the students to learn the concepts of science. According to a study conducted by us, students come across about 4000 concepts in the domain of biology, (excluding the names of all the species of plants and animals) upto higher secondary level of education (Thulasidas and Nagarjuna, 2001). However, the knowledge organizers required to understand these terms are not only constant but few in number. Our hypothesis is: if during the course of science education students are trained to think and study the world using knowledge organizers, *meaningful learning,* in contrast to rote learning, as explicated by Ausubel (Ausubel et. al., 1978), takes place. With this understanding when we explored for a set of required knowledge organizers for science (or for the domain of biology) from the literature, we could not obtain any such set readily available. This indicates that there is a need to develop an authentic set of knowledge organizers for use in science education. Our research objective is to fill this gap.

Representing anatomical details is more or less straightforward, since this knowledge can mostly be represented using *class inclusion, spatial inclusion, part-whole relations* (Winston et. al., 1987). But much of the core biological knowledge is contained in physiology, molecular biology, developmental biology, ecology, etc. Representing this knowledge in KR terms is often challenging. Based on our earlier analysis of biological terms, most significant knowledge of this field is expressed in terms of concepts that describe processes, states, or stages, and cycles. We make an attempt to explicate the general structure of these sciences to arrive at a definite KR for physiology. Since cell biology is a good representative for much of biology, we chose this area.

Many educational researchers have found it useful to adopt a network representation format for explicitly representing knowledge structure. There exists various methods to represent knowledge such as—concept map, knowledge Vee, Concept Circle Diagrams, SemNet, Conceptual Graphs. After analyzing the concept mapping methodology, we identified several problems on the basis of our knowledge organizers. These are discussed in an article, *Towards Principled Approach of Concept Mapping* (Nagarjuna and Kharatmal, Unpublished Paper). We find the conceptual graphs approach by Sowa (Sowa, 1984) is highly instructive and we plan to make use of this technique for representing scientific knowledge. Based on our understanding, we developed a model of KR and an application that can be used to undertake the task. The software application called GNOWSYS (Gnowledge Networking and Organizing SYStem) (see URL in ref.) is developed which helps to construct the set of organizers of scientific knowledge. An introduction to the Knowledge Organization (KO) model of this application will be discussed. In this work, we shall describe the methodology followed to construct the set of knowledge organizers using GNOWSYS for science education and illustrate the method for the domain of cell biology. We shall indicate how this methodology can be used in understanding the structure of knowledge, measuring cognitive significance of concepts, generality-specificity index of concepts, defining learning paths based on cognitive dependency relations, comparison of novice-expert's cognitive structures, etc.

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Concept Mapping – A Pedagogical Tool for Grammar Lessons

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Introduction

Grammar is the description of the regularities in a language. Knowledge of these regularities provides the learner with the means to generate potentially enormous number of original sentences. Grammar teaching can proceed in two ways: *covert grammar teaching* where the rules are taught to a communicative syllabus and *overt grammar teaching* where the rules of grammar are presented explicitly using the grammar syllabus. Looking at the prescribed textbooks and the teacher handbooks used in Indian schools, one can infer that the pedagogy of English grammar teaching in India, by and large, follows the overt method. The teaching relies heavily on explicitly stating the concept and the rules governing it. The inductive or deductive approach is then used to understand the syntax of the language and solving examples strengthens the rules hence learnt.

Concept Mapping has proven to be an effective pedagogical tool and a metalearning strategy useful for many subjects (Ritche and Volkl, 2000; Gardgill and Jitendra, 1999; Novak, 1990). Based on assimilation theory the concept maps are rooted in the principle that the single most important factor influencing learning is what the learner already knows (Bayram, 1995). Researches have suggested that concept maps can be used to facilitate meaningful learning. (Abram, 2001). The educators can find multitude uses of concept maps in their classrooms. Few studies have been carried out using this tool in teaching grammar (Boyle & Weishaar, 1997; Clements-Davis & Ley, 1991; Dimino et al., 1990).

Grammar is famous for its numerous interlinked concepts. Teaching grammar with its interlinked concepts is a challenge to every language teacher. As a teacher educator, the researcher chose to study the effect of using concept maps in teaching various grammatical concepts to the learners and to see whether learning through concept maps is likely to be more effective as compared to other pedagogical options.

Objective

To study the effect of the use of concept maps on the teaching and learning of English grammar.

Hypothesis

The use of concept maps is effective in the teaching and learning of English grammar.

The Plan of the Study

In view of the objective it was decided to conduct the experiment on class IX students of Army Public School, Delhi Cantt. The 94 students chosen for the study belonged to the two sections of class IX. One section was chosen to be the experimental group while the other the control group. An initial test was planned and administered. This test, based on the class VIII syllabus, aimed to check whether the two groups were comparable.

Keeping in mind the school schedule, it was decided that thirty teaching periods would be utilized per group to deliver the instruction. The topics chosen for the delivery of instruction covered two areas: Grammar and English prose. The prose lessons were selected to study the feasibility of using concept maps in learning the English prose lessons. The classes conducted covered: Parts of Speech, Direct – Indirect, Active Passive Sentences and from their textbooks (*Main Course Book,* published by the NCERT, New Delhi) Amundsen's Journey to the South Pole and Whales.

In sync with the objective, in the experimental group the instruction was to be imparted using concept maps and in the control group using the lecture method. In the experimental group the concept maps on grammar lessons were to be developed in the classroom using the student's pervious knowledge while in the prose lessons, as the prose proceeded.

The classes to be conducted with the experimental group and control group were to use only the prescribed textbooks and the available resources: blackboard and coloured chalks.

It was planned that after thirty lessons another test was conducted on the topics covered in the class. It was also planned the types of questions in the test did not favour any one methodology.

Delimitation

This being a preliminary study (to be followed up subsequently) a single school was chosen and only selected portions of the prescribed syllabus were covered during the study.

Analysis and Interpretation

Table 1 shows the mean and standard deviation of the two groups on the test conducted on class VIII syllabus.

The means, standard deviation and the spread of scores around the mean shows that two groups were comparable on the test taken before the study began.

Once it was established that two groups were comparable, the delivery of instruction took place in the respective methodology. On covering the decided topics

Table 1: Means, SDs and Dispersion of Scores on Test 1

Groups	Means	SD	Dispersion of Scores (in %)		
			$\pm\sigma$	$\pm 2\sigma$	$\pm 3\sigma$
Experimental	22.20	3.48	74.46	95.74	97.88
Control	19.57	3.62	70.21	95.75	97.87

Table 2: Means, SDs and Dispersion of Scores on Test 2

Groups	Means	SD	Dispersion of Scores (in %)		
			$\pm\sigma$	$\pm 2\sigma$	$\pm 3\sigma$
Experimental	24.22	3.66	63.82	100	100
Control	20.32	3.45	70.21	97.87	100

Table 3: Means, SD and t values for experimental and control group

Group (Class)	Test	Mean	SD	t test
Experimental 9 A	Pre	22.20	3.48	2.743 Significant at 0.01
	Post	24.22	3.66	
Control 9C	Pre	19.57	3.62	1.047 *Not Significant*
	Post	20.32	3.45	

another test was conducted on the same groups.

Table 2 shows that the mean score of the experimental group is higher than the control group showing thereby achievement is better.

The t test conducted separately on the experimental and control group scores on Test1 and Test 2, shows that the improvement in achievement in the experimental group is significant at 0.01 level whereas the t test does not show the same for control group.

Conclusion

Students who are imparted learning experiences through concept map signal a better performance on their understanding of the concepts of English grammar as compared to the ones taught through commonly prevalent options.

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Probing Nature of Links Amongst Physics Concepts

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Introduction

Novakian (Novak, 1998) concept maps represent meaningful relationships between concepts in the form of propositions. According to the D.P.Asubel's assimilation theory of learning, the cognitive structure of a student is organized hierarchically. Links between concepts are semantic relations. Our focus, in this paper is on classification of links amongst concepts in physics. Researchers have noted that knowledge acquisition is not just an accumulation of concepts but also comprehension of interrelation of these concepts (Mohapatra, 1995).

Methodology

We selected a group of 30 students studying physics in the B.Sc.program at the University of Mumbai. They had studied electrostatics during the earlier semester. We selected five core concepts in the area of Electrostatics, namely, Capacitors, Dielectrics, Charge distribution, Electric dipole and Conductors. Each of these concepts was presented to the students as a central concept. The students were asked to list in a given time, concepts related to the central concept.

We then prepared a grand concept map with the five core concepts listed above and 109 concepts generated by students. Their links and cross-links were carefully established. In this case, concepts are nouns or noun-phrases, whereas links between them are verbs or prepositions. The grand concept map showed clusters of concepts around nodes. These nodes included the five central concepts. Out of the five nodes 'capacitors' and 'Charge distribution' are prominent. This procedure of establishing links between the concepts is explained below.

Consider two concept labels "Capacitors" and "Direct Current"(dc). We have linked these two concepts by completing the following sentence:

Capacitor **blocks** *dc*.

In this case the verb '**blocks**' connects the two concepts, *capacitor* and *dc*. The link words are shown in bold type and the concept words are in italics.

Let us consider some more examples.

Capacitor **may have** *vacuum* **between** (its) *plates.*

Charges **can be** *like charges* and *unlike charges.*

Electric field **has** *direction.*

Having established the grand concept map with its links, we wished to probe further the nature of the links and to check whether particular types of links are more common in this map. We arrived at the types of possible links after consulting the literature.

Literature Survey

Nastase and Szpakowicz have given 44 types of semantic relations amongst noun and noun-modifiers (Nastase, 2003). Similarly, Sowa (Sowa, 1984) has listed 37 different types of semantic relations between concepts. Winston et al (Winston, 1987) have given taxonomy of part-whole relations. They have indicated six types of meronymic (part-whole) relations. Veda Storey (Storey, 1993) has identified seven types of semantic relations. One of the types, 'inclusion' consists of three subtypes class, meronymic and spatial. Their meronymic subtypes consists of seven subtypes, one more than those listed by Winston. Researchers (Rosario 2004) have examined the problem of distinguishing among seven relation types that occur between "treatment" and "disease". Rajwade et al (2001) have proposed a mechanism of quantifying the linkage of two concepts through a link number. In another paper the same authors (2003) have used this link number to develop a method for improving subject knowledge of students.

Sr. No	Class of relation	Example
1.	Causality	*Thermal energy* **disaligns** *electric dipoles.*
2.	Rate(Time)	*Charge flow* **per unit time** (is) *current.*
3.	Rate(Space)	*Current* **per unit area** (is) *current density.*
4.	Location	*Potential difference* **across** (its) *plates.*
5.	Arrangement	*Components* (can be) **arranged** (in) *series.*
6.	Source	*Charges* **come from** *battery.*
7.	Agent	*Capacitor* **blocks** *dc.*
8.	Measured by (Instrument)	*Potential difference* (is) **measured by** *voltmeter.*
9.	Measured in(Units)	*Potential difference* (is) **measured in** *volts.*
10.	Inclusion (class)	*Positive charges* **e.g.** *holes, electrons.* *Plates* **are** *conductors.*
11.	Inclusion (Member /collection)	*Charges* **make up** *charge distribution.*
12.	Inclusion (Component /Object)	*Capacitor* **may have** *dielectric.*
13.	Characteristics	*Like charges* **exert** *repulsive forces.*
14.	Attribute.	*AC* **has** *frequency.*
15.	Analogy	*Electric flux* ◄─► *Magnetic flux.*
16.	Function	*Charge density* **depends** (on) *charge distribution.*
17.	Representation	*Electric field* (is) **represented by** *Electric field lines.*
18.	Name	*Charge loss* **is** *charge leakage.*
19.	Synonym	*Insulators* ◄─► *Non-conducting medium.*
20.	Antonym	*Conductance* ◄─► *Resistance.*

Discussion of results

We have used the grand concept map to identify similar relations in physics. We looked at the kind of linking words used in connecting any two concepts in the map. A thorough survey of the map suggested 20 different semantic relations amongst the concepts used. These relations have been listed in the included table

The frequencies of occurrence of these relations in a grand concept map diagram will be given in the paper.

Conclusions and Future work

The set of relations listed above forms, by and large a subset of the relations found in the literature. It must be noted that many relations quoted in the literature are not found here. Instead, some additional ones have been included to account for the nature of the subject, physics.

For example, "rate" (with respect to time and space both) is a frequently occurring type of relation in physics and is not mentioned explicitly in the literature. Similarly, measurement being a special aspect of physics "measured in (units) "is a relation peculiar to physics. Also, "measured by" has been included separately, though it is a particular case of the relation "agent" found in literature. This is because of the importance of measuring instruments in physics. Also, "arrangement" of components of an object is important in the present context. Also, the idea of "analogy" is often used in physical sciences. Further "Function" and "representation' are two other relations which we believe will be special to physics, mathematics and needs to be included.

The limitation of this study is that it covers only one topic in physics. Further investigation, with different set of central concepts may confirm the above list. Such a study may throw up few additional relations as well. Also, frequency of these relations amongst physics concepts requires more detailed study.

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Effect of Concept-Mapping in Science on Science Achievement, Cognitive Skills and Attitude of Students

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Theoretical framework of the study

In order to improve instructional methods carried out in the classroom and improvement of students' learning, there have always been a search for more potential ways of instruction. One of the strategies that has evolved as a useful tool in leading students towards meaningful learning is 'Concept Map'. Concept mapping is seen as a useful tool for helping students learn about the structure of knowledge and the process of knowledge production or meta-knowledge. In contrast to students who learn by rote, students who employ meaningful learning are expected to retain knowledge over an extensive time span and find new related learning progressively easier.

The use of concept maps as a teaching strategy was first developed by J.D.Novak in the early 1980's, derived from Ausubel's learning theory which places central emphasis on the influence of students' prior knowledge on subsequent meaningful learning. Concepts maps are diagrammatic representations which show meaningful relationships between concepts in the form of propositions which are linked together by words, circles, and cross links. Concepts are arranged hierarchically with the Super ordinate concepts at the top of the map, and subordinate at the bottom which are less inclusive than higher ones. "Cross links" are used to connect different segments of the concepts hierarchy, which indicate syntheses of related concepts, a new interpretation of old ideas, and some degree of creative thinking.

In recent years, along with the various innovative methods ,constructivism in the classrooms as an interpretative process involving individual's constructions of meanings in science is being suggested. New constructions are built through their relations to prior knowledge and it is a pedagogic challenge for teacher to focus on students' learning with understanding. To learn science from a constructivist philosophy implies direct experience with science as a process of knowledge generation in which prior knowledge is elaborated and changed on the basis of fresh meaning negotiated with peers and teacher. Concept mapping stimulates this process by making it explicit.

This research paper is an outcome of an ERIC project, NCERT which aimed at investigating the use of concept mapping as a strategy to enhance meaningful learning and to improve upon the process skills of students in science.

Objectives of the Study

- To develop and implement concept mapping as a strategy in the selected few units of science for VIII standard students and study its effect on the achievement , concept attainment, and the process skills of students belonging to different intelligence groups.
- To study the attitude of students towards concept mapping in science.
- To study the gender differences in science achieve-

ment, process skills and attitude towards concept mapping.

Design and Sample of the Study

The study was quasi-experimental in nature wherein non-randomized pre and posttest design was used. The intact classes of eighth standard as a whole were considered as experimental (47) and control group(42) for the study, from two local schools of Mysore city.

Tools used in the study

Raven Progressive Matrix was used to group the students according to their intelligence. An achievement test based on selected units of the eighth standard syllabus, a process skills test and a concept attainment test were developed to measure the students' achievement, process skills and attainment of concepts in science. An attitude scale was developed to measure students' attitude towards concept mapping.

Procedural Details of the Study

The lessons in the selected units of science were developed based on constructivist model which included i) planning student exploration ii) explanation iii) expansion and iv) evaluation. The tools and the lessons were tried out and Item analysis was carried out in case of achievement and process skills test. The tools were administered to both experimental and control groups as pre-test. The project was implemented to the students of Experimental Group during which they were oriented about the steps involved in concept mapping followed by the implementation of the science lessons. Concept maps were evolved during the process of instruction along with the explanation. Concept maps were developed at the review stage on the blackboard with the help of students. The student constructed maps in groups as well as individually, were made to be presented and discussed. The concept maps were used as assessment tools in all the units.

The data obtained was analysed descriptively and inferentially by calculating percentages, mean, SD and "t" values and ANOVA.

Major Findings of the Study

i) The analysis of data revealed that the experimental group students had performed better when compared to the control group on the achievement test, process skills and concept attainment test on the post test occasion. This was evidenced through the "t" values obtained for achievement test (9.66); process skills (6.34) and the concept attainment test (4.40).

The analysis of students' (experimental) attitude towards concept mapping revealed that almost 90% of them had a very positive attitude.

ii) The F values obtained (5.921) showed that there is a difference between and within the different intelligence groups of the experimental group in their post-achievement test implying that the concept mapping strategy has had a differential effect on students belonging to different intelligence groups. Similarly, the F value obtained for concept attainment test was found significant implying that there is a difference within and between the students of different intelligence in their concept attainment ability. But there was no difference found either between or within the different grades of students in their performance of process skills.

iii) There was no difference observed between girls and boys in their achievement, process skills, concept attainment and in their attitude towards concept mapping.

Based on the results of this study, it is concluded that there is a need to include concept mapping with the constructivist basis as one of the major approaches to teach science in schools and provide workable strategies to help students "learn how to learn".

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Learning to Think: Lines of Research in Dianoia Project

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The Dianoia Project has been developing several lines of educational research pertaining to the area of Teaching and Learning to think since 1986. This contribution seeks to outline the theoretical foundations of these lines of research, describe them briefly, point out some results and products of the project and confront with others in this line, and take stock of some issues raised by the research done.

Within the conceptual framework of theories of intelligence developed in cognitive psychology, the Dianoia Project had as main objective the creation of models of pedagogic intervention in the various curriculum areas, aiming specifically at the improvement of learners' cognitive skills. The research carried out by Dianoia is distinguished both by its options of research and intervention inside the curriculum and by its focus on the use of metacognitive stategies.

The early phase of theoretical and experimental research work began in 1986. In its early stage the project issued a number of publications which were intended to diffuse not only the results obtained so far, but also this specific line of research. The second phase started in 1990 and has developed according to several lines of research, namely assessment of effects in compensatory education, problem solving in physics and mathematics and in pre-service teacher training. The research carried seems to confirm the potentialities of these interventions, while it raises some issues concerning other, non-cognitive, dimensions associated with the development of thinking.

Dianoia has been in essence an intervention project; the research conducted has been founded on a broad conceptualisation of intelligence which is not subsidiary to a single theory, but which rather gathers suggestions from various currents of research, which emphasise the role played of tactics in intelligent behaviour. The project is structured as an intervention directed towards the teaching of thinking; it offers suggestions for strategies and mechanisms that are considered to be able to promote a certain modifiability for the productivity of thinking.

In Dianoia the action research is conducted at the curriculum level. This is in line with the research - both theories and data provided by the latest work in the field - which advocates that learners learn about the use and control of their cognitive processes more effectively if they are taught directly within the various curriculum subject areas.. Besides this option directed to interventions in curriculum subject areas, Dianoia takes into account that thinking skills are acquired through the improvement of metacognition and therefore it has explored the possibility of promoting students' success through the convergence of teaching to think and teaching to think about thinking - metacognition.

The development of metacognition has proved effective in reading comprehension, in knowledge retention and retrieval, and in problem solving. Beyond the acquisitions of skills, the learner learns how to control his learning, becomes better informed, more independent and pursues a goal in his learning and also focuses more on tasks by controlling his attention. Metacognition may thus be regarded as the key ability.

As metacognitive thinking does not develop naturally, instructions have been designed to train metacognitive thinking directly and explicitly.

To make possible the acquisition by learners of a vast range of thinking skills, from the most elementary such as remembering, recognizing, comparing, and inferring, to the most complex such as problem solving, decision making, thinking creatively and critically, it is crucial to train learners in a systematic way how to use and regulate these skills. But it is also crucial to teach them directly and explicitly as well as to instruct learners about the benefits the use and regulation of thinking skills can offer them.

Indeed, learners are not to be expected to develop spontaneously such skills; nor does the study of any given subject necessarily imply that learners are likely to acquire the thinking skills they are badly in need of to evaluate and apply the subject knowledge in situations other than those in which they learn it.

Conceiving any cognitive training presupposes a definition and description as clear as possible of the skills to be trained before setting them as learning objectives and developing instruments for their measurement, by focusing on learners' cognitive and metacognitive behaviours, thus measuring the training efficacy.

In short, Projecto Dianoia's general methodology is characterized by being a methodology of intervention which capitalizes on the purposeful, systematic, and direct teaching of thinking strategies permanently reinforced by metacognition. Learners are continuously stimulated to be aware of, and control their own mental processes while they learn curriculum contents.

Such methodology is developed and tailored in different ways to meet the learning situation found and learners' age level. Diversified learning strategies placing more or less emphasis on learners' awareness and control of mental processes are then developed according to the specificity of situations.

Although Projecto Dianoia has developed its action based on the assumption that thinking teaching is more effective when done within the standard curriculum, Dianoia researchers consider it an unresolved issue. Their option can be accounted for by the following reasons:

- the act of thinking relates closely to the specific fields of knowledge, which is not conducive to conceptualize its instruction and learning out of any corps of contents;

- once confronted with unknown situations, the learner always tries to interpret them, and think about them, by using what he/she already knows, which seems to account for the teaching of thinking skills in specific contexts, familiar to the learner;

- studies developed recently in the area of problem solving in specific knowledge domains have shown the existence of strong interactions of knowledge structures and cognitive structures.

Levels of Inquiry: Role of Language & Assessment

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Purpose of the Study

This paper-presentation is based on my observations and analysis of my students and my discourses and inscriptions as I engaged them in the process of learning how to teach science at the elementary grade levels.

Introduction & Significance

Science education reform efforts around the world are focusing on teaching and assessing science learning with emphasis on inquiry where the learners construct their own knowledge (Bruner 1960, Driver 1983, Glasersfeld 1998, Lemke 1990, NCERT, 2000; NRC 1996). This concept of knowledge construction, often called constructivism, has revolutionized teaching and learning of mathematics and science. Glasersfeld (1992) emphasizes that the foundation of any learning process is language and the meaning different people assign to objects, events, and experiences. Mental abstractions of sensory materials construct concepts. Bloom (2001) further explains how this process of inquiry and knowledge construction is language dependent. Discourses that happen in a science classroom are distinctly apart from day-to-day life discourses and may even be categorized as a discourse in a "new" language – the language of science (Lemke, 1990). Language of science is like an "Auntie-Tongue" – the language of the elite (Dasgupta, 1993). These discourses influence the inscriptions (written descriptions) of both the learner (student) and the learned (teacher). Ultimately, these discourses and inscriptions establish the assessment and evaluation practices and their results. By recording and analyzing the above described experiences, we are able to shed more light on the complex process of learning and teaching and hopefully be able to help ourselves and others in becoming better learners and teachers of science.

Research Approach

Data Collection: For the past twenty years I have worked with students from primary to college level at various schools and colleges in India and United States of America. The data that forms the basis of this paper is based on selected samples of these students' work and some of the discourses I have had with these students either individually or in a classroom setting. I did not begin this study with any particular purposeful question to investigate. I was simply teaching and attempting to become a better learner and teacher of science and help my students become better learners and teachers of science. In research literature, such studies are categorized as phenomenological studies.

Philosophical Basis: Phenomenology does not provide a prescription for conducting research but presents a script after the play is played and the curtains are drawn. This script explains the process that was involved in arriving at the conclusions and the suggested implications. (Berger & Luckmann, 1966; Bogdan & Taylor, 1975; Lincoln & Guba, 1985; Maanen, 1988). I, the researcher, was the key instrument of data collection. Using myself as an instrument enabled me to be responsive, consider the circumstances, adapt techniques to the situation, analyze the data instantly, and clarify and synthesize as the study evolved (Lincoln & Guba, 1985).

Data Analysis: Data analysis was conducted simultaneously with the data collection phase. I highlighted specific aspects of my classroom discourses and asked my students to do the same regarding their inscriptions. This was followed by categorizing the data following open coding, i.e., each phenomenon was given a name and generally the names were "in-vivo", that is, words from the data itself were used to label or code the data (Strauss & Corbin, 1990, p. 69). These codes were synthesized to form "main-codes" followed by further synthesis into "meta-codes". A report was compiled for each of the "meta-codes". Based on this report I was able to arrive at various themes that included the "main" as well as the "open" codes. From time to time, I have shared my analysis with my students for member-check (Lincoln 1985) and they have helped me further evolve and refine these themes.

Discussion

Based on the data analysis the following themes were obvious:

Science learning and teaching happens at different levels of inquiry depending on who is constructing what knowledge and how it is being constructed. For example, who poses the questions/problems, who is responsible for devising the procedures, who is finding the solutions or who is replicating what is already known (Bonnstetter, 1998).

Language plays a critical role in this process of knowledge construction. For example, often when asked to "explain" (infer) a phenomenon, my students will "describe" the phenomenon and vice-versa. Similarly, "objects float because they are light" is often expressed because that is what is commonly believed and unfortunately written in many textbooks, including the ones my students use.

The native speakers of English have no particular advantage over non-native speakers in the process of learning science using the English language. Even for the native speakers the language of science is a "new" language often perceived as a foreign language and/ or the language of the "elite".

Ultimately, the level of inquiry and language determines the nature of assessment and evaluation practices.

During my presentation, I will show several examples of the raw-data, followed by how the data was analyzed and the reports complied followed by how I arrived at the above conclusions.

Implications

Constructing scientific knowledge in an inquiry-based instructional setting is absolutely dependent on language skills and processes irrespective of the language of instruction. Even for people who speak just one language and are instructed in that language, the process of inquiry and knowledge construction in science is experienced as a "new" language acquisition. This does not mean that we teach science as a language acquisition process but guide the learner to evolve and explain their ideas and connect those to language and math instruction they are receiving. This demands that the science, math and language curricula be aligned both horizontally and vertically.

To facilitate construction of knowledge the learner has to be provided with the opportunity to construct and communicate that knowledge at different levels of inquiry and this process should make connections between the learners', peers', teachers' and the scientific language.

There is a need for the learned and the learners to comprehend the complexity of the discourse that happens in science classrooms to enable instructive feedback loops. The ultimate aim being the establishment of demanding and yet successful science learning and assessment experiences for ALL learners.

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Culture, Language and Cognition

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The dominant discourse in natural and social sciences insinuates an understanding of culture/language and cognition as essentialistic, formally invariable, biologically conditioned, universally univocal and linearly scalable entities, and pleads for a single universal language of thought and knowledge, and their expressions (the so-called Western science, mathematics, technology with its inherent ethnocentric, patriarchal and educational canon!).

But in recent years a critical work of deconstruction and decentring originating from different sources has taken place, for the sake of establishing universally accepted epistemological standards in the sociology of scientific knowledge and of acknowledging the contributions of a variety of cultures, groups (women, subalterns) and practices trying to master local indeterminacies.

A standpoint, which is embedded in historical situated consciousness with an international comparative horizon and mindful of our contextual rootedness as being and becoming in a concrete world, will, certainly, approach culture, language and cognition as characterised basically by diversity, without overlooking the phenomenological similarity that underlies them. All three have one thing in common, namely that they are shaped by a pluralism of signs, meanings, expressions, knowledge and order systems within a symbolically constructed community with open or closed boundaries.

This approach takes furthermore into consideration the fact that culture, language and cognition as indicators of belongingness to a social or scientific group, which seeks to realise itself as a collective subject, is traversed (constituted and/or constrained) by unequal relations of power, by divergent world interpretations, by multiple types of expressions and distinguishing modes of conceptualisations, which are ranked in their status according to a scale of superiority or inferiority, dominance and subordination.

This paper will review and present accordingly

- an explanation of culture as a dynamically and non-homogenously constituted configuration of knowledge, beliefs, value and behaviour patterns, which, even though not free from ambiguities and contradictions, are (or can be) bearers of universally valid core messages;
- an interpretation of language not just as spoken and written word but basically as a conceptual metaphor pointing to many other modes of expression of our thoughts, feelings, communication practices, artistic and aesthetic visions, musical emotions, technical and architectural designs;
- and an understanding of cognition as a way of perceiving the reality, of conceptualising the self, the other and the world, of categorizing experience, of dealing mentally with thought and images and of building representational codes, that are characterised by multiperspectivity and contextuality, situated both at the individual as well as social level of analysis.

Challenges in Measurement of Scientific Attitude

Leena Deshpande
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Development of scientific attitude is considered as an important objective of science learning all over the world. Many teaching techniques are evolved and suggested to develop scientific attitude. Some out of them are the outcome of elaborate efforts of researchers. The challenge remains with the measurement of effects of these techniques. In other words it is a challenge of measurement of learning of scientific attitude, which is discussed at length in this write up. During the course of my work in the area of scientific attitude for the last 25 years, I have come across these challenges and tried to face them. This paper is aimed at making teacher educators, teachers, research students and also NGOs in the field aware of these challenges.

Following are some of the major challenges in measurement of scientific attitude

1) Conceptualizing
2) Domain decision
3) Content validity
4) Selection of right type of measuring instrument
5) Objectivity
6) Teachers training

The challenge of conceptualizing

Scientific attitude comprises of many complex factors. Only some of them are listed below after detailed study of related literature.

a) Belief on cause and effect relationship.

b) Suspend the judgment till enough data is gathered.

c) Emphasis on empirical evidence.

d) Open mindedness.

e) Accuracy in thought and action.

f) Intellectual honesty.

g) Objectivity.

h) Criticality.

i) Unbiased decision making ability.

j) Ability to identify difference between hypothesis and facts.

k) Habit of reviewing the data.

l) To keep away oneself from blind beliefs.

m) Curiosity.

n) Ability to think logically.

o) Faith in development.

p) Faith in problem solving.

q) Ability to recognize self limitations.

r) Interest in newness.

Apart from above sub-factors of scientific attitude, scientific temper and scientific outlook are the concepts having a very close relationship with scientific attitude. Under such circumstances, it is mandatory for test constructor –

- To understand and define each factor of the above list by dictionary meaning and also by some examples.
- To identify some similarities and differences in these factors.
- To classify them into sub-categories.
- To limit to some of these factors for the purpose of measurement so as to make the measuring instrument usable.
- To make operational definition of scientific attitude.

In the process of limiting to few factors and converting those into operational definitions, the totality of the concept and as a consequence the totality of measuring instrument is likely to be threatened.

Apart from this, the selected factors (which will define scientific attitude) may not be easily convertible in the test items in spite of best efforts of defining them operationally.

The challenge of domain decision

Psychological variables are generally categorized into three domains. These are cognitive, affective and psychomotor. The domain of the variable which is to be measured needs to be fixed for two reasons.

a) It helps in deciding right type of measuring instru ment.

b) It also helps in writing appropriate test items.

The test constructor faces the challenge in making this decision as attitude is generally categorized as a factor of the affective domain. But if we look at the factors given above, which comprise scientific attitude, we realize that only one single domain is not sufficient to encompass all the factors. Categorization of each factor under some single domain will also be artificial. Still if tried, factors like objectivity, criticality, unbiased decision making ability, ability to identify difference between hypothesis and facts will have to be categorized under cognitive domain. Where as factors like intellectual honesty, habit of reviewing the data, faith in development, faith in problem solving will occupy space in affective domain. A factor like accuracy in action will go under the psychomotor domain.

The challenge of content validity

A decision of content validity is the next challenge for the test constructor. The development of scientific attitude starts from learning of science. But later on, it is expected to exhibit its presence in all walks of life. So the content is too vast for the test or it can be said that it will not be limited to the specific content. To select the sample content for construction of scientific attitude test items from general experiences is not an easy task.

Another issue in this is how one can guarantee transfer of scientific attitude from one area to another, i.e. the person having scientific attitude in health related issues may not have it in issues related to religion.

Challenge of selection of right type of measuring instrument

Witnessing concrete evidence of scientific attitude through objective measuring instrument is extremely difficult. Attitude is defined as a stable predisposition to respond. This stability is understood either

(a) As a consistency across modes of responding to an attitude object.

Or

(b) As a consistency in individual responses across time.

Such an analysis suggests the inadequacy of the usual procedure of measuring attitude at a single time by attitude scales and calling these responses attitude.

Scientific attitude cannot involve only a measure of final product. The process also becomes important with the use of word scientific, as this word refers to the way attitude is developed. If an attitude scale is constructed and the test item asks to give favorable or unfavorable response to the statements then this response alone may not provide enough information about scientific attitude because the process invloved in reaching to this response cannot be revealed.

The test items for measuring scientific attitude need to measure cognitive, psychomotor and affective aspects. So varied types of test items need to be constructed. A routine type of attitude scale will not serve the purpose. Multiple types of tests and test items need to be thought.

Challenge of objectivity

Whichever is the tool chosen for measurement of scientific attitude, it will carry along with it numerous problems of objective measurement because of the complexity of the phenomenon. It is observed that experts in the field hardly come to a unanimous opinion about scientific attitude as a procedure and also as a product. It affects adversely on inter-examiners' objectivity.

Challenge of teacher training

Teachers hardly get any training of construction of scientific attitude measurement test at pre-service or in-service training programs. This training is essential as the standardized tools are rarely available and even if they are available they may not serve local purposes. Teachers training institutes need to think in this direction. It is seen that this major objective of science teaching is neglected in evaluation, measurement process and so as a consequence of this it is neglected in teaching too. At S.N.D.T. Women's University, we have done some efforts at pre-service teachers training programs, at M.Ed. and at doctoral research level to orient and to provide some experiences to our students regarding measurement of scientific attitude and have tried to over come some of the above said challenges.

The Effects of Metacognitive Instruction Embedded within Asynchronous Learning Network on Scientific Inquiry Skills.

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During the last decade, much research has focused on Asynchronous Learning Network (ALN). Although the technology seems to have the potential to enhance students' achievement, empirical findings have been inconsistent. Whereas a few number of studies reported positive effects of ALN on achievement, others have shown no significant differences between ALN and control groups, and still others indicated that ALN students performed less well compared to their counterparts studying under face-to-face interaction (Michalski, 2003).

Why has ALN only limited effects on students' achievement? At least two factors may explain this phenomenon. First, ALN is only one segment within a learning environment, and therefore ALN in itself is not sufficient to enhance learning. Second, and most important, students (and teachers) lack the skills needed to learn effectively in ALN environments. For example, analyzing students interactions in ALN environment indicates that quite often students do not activate metacognitive skills during their learning, and therefore their discourse through ALN is disoriented, unfocused, and not effective enough for enhancing higher-order cognitive processes. These findings raise the need to provide metacognitive instruction within ALN environment. The purpose of the present study is, therefore, to develop metacognitive instructional method appropriate for ALN, and to examine its effects on scientific inquiry skills as compared to ALN with no metacognitive instruction or to metacognitive instruction implemented within traditional, face-to-face learning environment.

What kind of metacognitive instruction would be appropriate for ALN? To address this question, we reviewed empirical studies that focused on the outcomes of metacognitive instruction. On a different line of research Mevarech and Kramarski (1997) and Kramarski and Mevarech (2003) developed metacognitive instructional method, called IMPROVE that significantly improved students' achievement in mathematics. IMPROVE was designed on the basis of current research in cognitive and metacognitive psychology. IMPROVE students study in small groups, using self-addressed metacognitive questions that guide their learning. The series of questions include: Comprehension questions (e.g., What is the problem all about?) ; Connection questions (e.g., How the problem at hand is similar to or different from problems you have solved in the past?); Strategic questions (e.g., What strategies are appropriate for solving the problem and why?); and Reflection questions (e.g., Does the solution make sense? Can you solve the problem differently, how and why?).

In a series of studies, including the above mentioned ones, Mevarech and Kramarski showed the effects of IMPROVE on different kinds of mathematical reasoning, and various components of students' discourse. In these studies, IMPROVE students significantly outperformed students who studied individually. The effects were observed on higher and lower achievers, as well as on different kinds of cognitive levels. Furthermore, the effects were evident immediately after the study, as well as a year later.

Although these studies were implemented in traditional, face-to-face classrooms, we hypothesized that metacognitive instruction embedded within ALN environment would largely improve students' achievement. Furthermore, there is reason to suppose that metacognitive instruction has the potential to enhance not only mathematics achievement, but also science achievement, and in particular scientific inquiry skills that required the activation of metacognitive processes.

Given the above review, we designed an innovative learning environment, called **MINT**, the acronym of the components composed the instructional method: **M**etacognitive guided **I**nquiry within asynchronous Learning **N**etworked **T**echnology. We hypothesized that students' exposed to **MINT** will improve their general and domain-specific scientific abilities.

To address this issue, we investigated the effects of four learning conditions on students' scientific inquiry skills. The four learning conditions are: (a) Metacognitive instruction embedded within ALN, (MINT); (b) ALN with no metacognitive guidance; (c) Metacognitive instruction embedded within face-to-face interaction; and (d) Face-to-face interaction with no metacognitive guidance. In the present study, the scientific inquiry processes included both general and domain specific inquiry skills in microbiology, and the metacognitive instructional method was adopted from IMPROVE.

Participants were 407 tenth grade students who studied in eight classrooms, two classrooms under each condition. Intact classrooms were randomly assigned into condition. All students, under all conditions, studied the unit Invitation to Inquiry. They all used the same learning materials for the same duration of time. The unit Invitation to Inquiry reflects PISA approach regarding science literacy. Students were administered a battery of pretests and posttests that assessed students' scientific literacy, including general scientific abilities and domain specific knowledge in microbiology.

Results indicated no significant differences between conditions at the beginning of the study, but significant differences between conditions at the end of the study. The differences were observed on both posttest measures: general scientific abilities and domain-specific inquiry skills in microbiology. Further analyses showed that MINT students significantly outperformed all other groups, whereas face-to-face with no metacognitive guidance (condition d) acquired the lowest mean scores; no significant differences were found between the other two groups (conditions b and c). The positive effects of MINT were observed mainly on the following cognitive skills: comprehending scientific problems. planning experiment, identifying main variables, suggesting appropriate analyses, and drawing conclusions on the basis of scientific evident.

The findings indicate that MINT makes significant contributions to students' achievement in science literacy, particularly to designing experiments and drawing conclusions on the basis of scientific evidence. The theoretical and practical implications of the study will be discussed at the conference.

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An Overview of the Development of Learning Standards for Science and Mathematics Education: KG – 8

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Significance and Objectives of Study

Learning Standards are a set of clear statements broken up class and subject-wise specifying the key educational objectives that must be achieved by students at that stage in that subject. They seek to answer *what* must be learnt, sometimes covering a bit of the *why* in the process, but leaving the *how* (and even the details of the *what*) to the school or the teacher.

India does not have a comprehensive Learning Standards document. The NCERT-developed Minimum Levels of Learning (MLL's) are often considered as the graded learning expectations for schools in India. The MLL's are framed in such a manner as to be mechanistic, mentioning highly specific, fragmentary learning objectives in terms of observable behaviour while ignoring the underlying understanding desired (The Great Indian Tradition - Padma M. Sarangapani).

The goal of the current project was to identify, understand and bridge some of these gaps, and to develop Learning Standards (for Science, Mathematics, Social Studies, English and Hindi) that ensures a minimum quality by clearly specifying expectations, while reducing ambiguity and disparities between schools and regions.

Research Design and Procedure

The project consisted of two exercises – (1) a comparative study of Learning Standards and other curricular documents of various countries and the Indian Boards of Education and (2) framing of Learning Standards.

1. Comparative Study

In the process of designing Learning Standards for KG-8, a detailed review of what other countries do in K-8 education with what is being done in India was carried out by analyzing the curricular documents and textbooks available.

List of Countries Selected for Detailed Review		India
Science	Mathematics	
Canada(Ontario) Singapore United Kingdom USA (NSES & Virginia)	Japan Singapore United Kingdom USA(NCTM & California)	NCERT Framework; MLL; CBSE , ICSE (Anglo–Indian Board),and syllabus documents of various State Boards

The purpose of this exercise was three-fold. (1) to understand what children of other countries learn and are able to do (2) to consider what other countries consider important to teach in schools and (3) to draw upon the base of study done in other countries that can be used in India.

2. Framing of Learning Standards

An analysis of available concept-age maps, child development theory, curricular theory, common errors and shortcomings in children's thinking and learning were also considered while developing the Learning Standards. The content, structure, and clarity of the Learning Standards have been validated by subject experts. Feedback was obtained from subject teachers from a cross section of schools in India.

Findings

Some of the key learnings from the comparative study:

1. Singapore is unique as compared to other countries studied in that the content in science is organized into 5 themes (subject areas) namely Diversity, cycles, systems, Energy and Interactions.

The National Science Education Standards of USA includes Nature of Science elements into the curriculum.

2. Ontario introduces design as an important component in science learning.

3. Singapore and India's Minimum level of Learning introduces science from class 3 while the rest of the countries studied have science from Kindergarten or class 1.

4. Mathematics syllabus of Singapore does not group topics into strands/ areas of study (like Numbers, Measurement, Geometry, Algebra, Statistics, etc) that run through all the grades, instead handles the topics without such grouping.

Different topics in Mathematics are introduced in different classes across the countries (For example, Alberta introduces 'probability' in Class 1, National Council for Teachers of Mathematics – USA introduces from Pre K- 2, England does the topic from class 3-6 while Singapore handles probability only in class 8).

Some of the core recommendations made in the Learning Standards document:

1. For Science Education

a) The current focus in the Indian curriculum is on teaching facts, and development of *skills* is not being emphasized. Students need to acquire skills necessary for scientific inquiry and the skills necessary for the workplace.

b) The curriculum should emphasize understanding about the *applications* of science and technology in real life, so that students can relate/apply the knowledge acquired for real life solutions.

c) Emphasis should be on making the students aware about the *nature and history of science* (for example, what is currently believed as truth in science may not have been so in the past or in the future).

d) The curriculum should create awareness in students towards the existence of patterns and *unifying concepts* in science, as this will enable them to look at the big picture.

e) It is recommended that some abstract concepts be introduced later than is being currently done (for example, existence of gases is not to be done before grade 4. Young children think of air as 'emptiness' or 'nothing' and find ideas like 'air is a material substance' / 'air is made of gases' difficult to grasp.[1]).

f) Mental health should be included in Biology from grade 2 onwards (for example, children should understand that talking to someone may help people understand their feelings or problems and what to do about them[2]).

[1] Jayashree Ramadas, Small Science - Class IV, Homi Bhabha Centre for Science Education., p.81

[2] American Association for Advancement of Science and National Science Teachers Association, Project 2061, Atlas for science literacy, p.93

2. For Mathematics Education

a) The goal of Mathematics teaching is to develop in children *mathematical thinking*, teach them *procedures* and also create a *positive attitude* towards Maths. There is a feeling that the current curriculum focuses mainly on the second of these (i.e. teaching Maths procedures). One way of encouraging Mathematical thinking is to build concepts gradually clearly showing the links and patterns underlying different concepts.

b) Students should be taught the *applications of various concepts* so that they are able to apply them efficiently and effectively in everyday life.

c) Increased emphasis should be laid on '*problem solving*' i.e. the children's ability to tackle problems that are conceptually challenging and which have not experienced before.

d) *Fraction operations should be de-emphasized and decimal sense strengthened* as that is what is used mostly.

e) Emphasis on *mental maths* (precise calculation mentally) and *estimation* (rough calculation) skills, *visual and spatial skills* (understanding symmetry and shapes) should be increased.

f) The basics of *statistics* should be introduced early.

Acquisition of Process Skills by IV Standard Pupils through an Instructional Programme in Environmental Studies

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Introduction

An Environmental study is a human enterprise through which we come to some understanding of the Biological, Social and Physical aspects of the world around. Their understanding involves the development of ideas or concepts, which enable related situations, objects or events to be linked together, so that past experience enables us to make sense of new experiences. The cognitive process of relating to experiences and learning content requires the usage of process skills. Thus process skills consist of following skills (Harlen, 1993), Observing, Question-raising Designing and Making, Predicting, Hypothesizing, Communicating Effectively, Devising and Planning investigations measuring and Calculating Finding patterns and Relationships, Manipulating Materials and Equipment effectively.

The focus of the present study is on acquisition of process skills by IV standard pupils. The acquisition of process skills is realized through pupils' ideas and change in pupils' ideas within the 'context' of scientific investigation created through an instructional programme in environmental studies.

Significance of this study

The various policy initiatives on Environmental studies place emphasis on *'learners to relate and understand their surrounding environment'*. (NCERT, 1981, 2000). The research efforts to translate these policies into practice have resulted in development of Instructional programme for teachers and pupils (Lobo, 1990 and Sharma, 1994). The instructional programme developed to understand the process skills were based on Linear model of process skills, where the process skills were assumed to be arranged in a linear fashion, which develops in isolation, independent of content and context. The idea that once developed, these skills tends to be transferred to other content areas has been criticized by Harlen (1986), Roth and Roychoudhury (1993). In light of the criticism on linear model, an alternative model based on constructivist approaches has been proposed by Harlen (1993). The emergence of this alternative conceptual learning model makes it imperative to refine and question the utility of Instructional Programmes based on linear model of process skills. Therefore, there is a need to develop Instructional programmes based on alternative model of process skill development.

Process Skill Development – An Instructional Frame Work

When process skill development is viewed from the perspective of conceptual learning model (Harlen, 1993), learning is seen as modification or expansion of pupil's exisiting ideas. These ideas result, when pupils, teachers interact with learning experiences. This learning involves the processes of planning, implementation and evaluation of learning experiences. It is in this context, instruction as a process emerges, since the primary purpose of instruction is to cause learning. Thus instruction is an intentional, interpersonal process (Anderson & Burns, 1989) meant for planning, implementing and evaluating the learning experiences. In other words, instruction is a plan of action, implemented to modify or expand the pupils initial ideas.

The emergence of constructivist approaches provides an instructional framework for process skill development. In this regard the instruction framework for the present study is derived from the constructivist model of curricular development (Driver, 1988). In this model, instruction is seen as a continuous process involving the aspects such as planning, implementation and evaluation. These aspects are interrelated and interact with each other and constitute a 'whole'. Instruction guides the planning, implementation and assessment of learning strategies and materials. In turn planning, implementation and assessment procedures, shape the instruction by facilitating the design of learning strategies and materials.

The process skills were assumed to act as 'whole' and influence the conceptual learning among pupils. This assumption along with the constructivist approaches to learning and researchers' practical knowledge of the school were the basis on which an instructional programme was conceptualized in Environmental studies.

Objectives

To prepare an Instructional Programme in Environmental Studies for IV Standard pupils.

To implement the prepared instructional programme in environmental studies for IV Standard pupils.

To identify the process skills employed by pupils during the Instructional Programme.

To study the acquisition of process skills employed by the pupils during the Instructional Programme.

Instructional Programme

In the present study the Instructional Programme was meant to provide instructional support to teacher. This instructional programme was prepared with respect to three topics (Soil, Sound and Water evaporation from 4th standard, Environmental Studies text book of Karnataka state Government). The Instructional programme consists of following components: Instructional materials for teachers, Lesson plans, Instructional sheets for pupils, Teaching strategies and Assessment procedure.

Research Design

The data collection approaches were qualitative and were governed by 'Case Study' Methodology. A rural primary school in Karnataka was purposively chosen as a Case study school. The researcher took the role of a teacher to collect data from IV standard pupils. The data was collected through Participant observation, In-depth interviews and documentary analysis for a period of six months. The data from participant observation, documentary analysis and in depth interviews were used to prepare field notes. The data analysis consists of reading and re-reading the field notes. The emergent patterns were listed in terms of interactions with pupils, teachers, parents and classroom. The patterns were triangulated to construct the meaning on the preparation of Instructional programme.

In order to identify the process skills employed by pupils during the instructional programme, pupils' ideas were grouped according to pupils' activities across three topics. The recurring patterns in pupils' ideas were coded and categorized to construct meaning on a particular activity. The meaning that evolved for particular activity was constructed. This meaning was compared with process skill indicators (Harlen, 1993) to identify process skills employed by pupils for each activity. The process skills employed by the pupils indicated ideas related to process skills. Pupil's ideas were further categorized for each activity to identify the change in pupils' ideas. The change in pupils ideas obtained for each activity was triangulated to construct meaning on the acquisition of process skills through instructional progamme.

Findings

In the present study the findings of the study have been expressed as four assertions. They are as follows:

Assertion One: Instructional programme in environmental studies facilitated the teacher in evolving teaching strategies for enhancing teacher-pupils interactions during the acquisition of process skills.

Assertion Two: During the context of scientific investigation pupils expressed autonomy in learning through interactions with teachers and with fellow peers.

Assertion three: Pupils proposed hypothesis based on certain concepts to explain the occurrence of events during the context of scientific investigation.

Assertion four: Pupils showed willingness to change ideas in the light of evidence.

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epiSTEME-1 Conference Programme

Dec 13 Monday			
9.30 to 10.00	Inauguration by Prof. B. V. Sreekantan, former director, TIFR		
10.00 to 11.00	David Treagust	Science Education	Review talk
11:00 to 11:30	**Tea break**		
11:30 to 12:30	Probal Dasgupta	Language and Cognition	Review talk
12:30 to 2:00	**Lunch**		
2:00 to 3:30	Yung Sik Kim	Science Education	Problems and Possibilities of "General Science Education" for College Students
	Anita Roychoudhury	Science Education	Data Evaluation: An Integral Part of Learning Science
	V.G. Jadhao	Science Education	The Concept of Force
	Mridula Ranade	Science Education	Science Teaching Through Computer Assisted Instruction
3:30 to 4:00	**Tea break**		
4:00 to 5:30	Sadhna Saxena	Science Education	Teacher as Constructor of Knowledge: An Analysis of Teachers' Contribution to the HSTP
	Nelofer Halai	Science Education	Understanding Science Teaching and Conceptions of the Nature of Science in Pakistan
	Abhijeet Bardapurkar	Science Education	Students' Explanations: A Review of how Students Understand the Theory of Evolution
	Purvi Vora	Science Education	Project Yuva: The Design of a Case-Based Multimedia Environment for Pre-Service Teachers.
5.30 to 6.00	**Tea break**		
6:30 to 8:30	Marc de Vries	Technology Education Workshop*	
Dec 14 Tuesday			
9:00 to 10:00	G. Nagarjuna	Models of Cognition	Review Talk
10:00 to 11:00	Kaye Stacey	Maths Education	Review Talk
11:00 to 11:30	**Tea break**		
11:30 to 12:30	Barbara Jaworski	Maths Education	Inquiry as a Tool and as a "Way of Being" in Mathematics Teaching Development
	Bodil Kleve	Maths Education	Teachers' Implementation of a Curriculum Reform

	Usha Menon	Maths Education	The Teaching of Place Value - Cognitive Considerations
12:30 to 2:00	**Lunch**		
2:00 to 3:30	**Poster session 1**		
3:30 to 4:00	**Tea break**		
4:00 to 5:30	Orit Zaslavsky	Maths Education	Transparent Objects and Processes in Learning Mathematics
	Rakhi Banerjee	Maths Education	'Term' as a Bridge Concept Between Arithmetic and Algebra
	C.K. Raju	Maths Education	Math Wars and the Epistemic Divide
	Senthil Babu	Maths Education	Tamil Mathematical Manuscripts and the Possibility of a Social History of Maths Education
6:30 to 8:30	Marc de Vries	Technology Education Workshop*	
Dec 15, Wednesday			
9:00 to 10:00	Michael Matthews	History – Philosophy of Science	Review Talk
10:00 to 11:00	Marc de Vries	Technology Education	Review Talk
11:00 to 11:30	**Tea break**		
11:30 to 12:30	Punyashloke Mishra	Technology Education	Visions and Mandates: An Analysis of Three Indian IT Curriculum Guides
	Sugra Chunawala	Technology Education	Placing Technology Education Within the Gender Perspective
	John Backwell	Technology Education	The Design and Development of Cognitive Acceleration Through Technology Education: Implications for Teacher Education
12:30 to 2:00	**Lunch**		
Excursion			
Dec 16, Thursday			
9:00 to 10:00	John Sowa	Knowledge Representation	Review Talk
10:00 to 11:00	S.C. Agarkar	Cultural issues	Cross-Cultural Research in Learning Hurdles in Science and Mathematics
	Ravinder Koul	Cultural issues	Epistemological Stances Towards Knowledge in School Science and the Cultural Context of India

	Thomas Stern	Science Education	Cooperation between Schools and Universities as a Catalyst for the Professional Development of Teachers
11:00 to 11:30	**Tea break**		
11:30 to 12:30	Verdiana Masanja	Gender issues	Gender Disparity in Science and Mathematics Education
	Satyendra Giri	Gender issues	High Achievement in Mathematics and the Girl Child
	Anjana Arora	Language and Cognition	Levels of Inquiry: Role of Language and Assessment
12:30 to 2:00	**Lunch**		
2:00 to 3:30	**Poster session 2**		
3:30 to 4:00	**Tea break**		
4:00 to 5:30	Bronislaw Czarnocha	Maths Education	Teaching-Research and the Design Experiment - Two Methodologies of Integrating Research and Classroom Practice
	Patrick Dias	Language and Cognition	Culture, Language and Cognition
	T. V. Venkateswaran	Cultural issues	Words and World-Views: Scientific Technical Terms in Tamil
	Zemira Mevarech	Assessment	The Effects of Meta-Cognitive Instruction Embedded Within Asynchronous Learning Network on Scientific Inquiry Skills
Dec 17, Friday			
9:00 to 10:30	Conference Review and Discussion 1		
10:30 to 11:00	Tea Break		
11:00 to 12:00	Conference Review and Discussion 2		
12:00 to 1:00	Lunch		
***Satellite Workshop of the conference. Participation open to all registered delegates**			

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