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 (X1 – X7) to the prediction of students’ academic achievement (X8)?

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% (R² = 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.

References

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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.

References

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).

References

Students’ Explanations: A Review of How Students Understand the Theory of Evolution
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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 collaborating 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 (Suspensive 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 sensitize 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.

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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 emphasis 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.

References
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:

- 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.
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.

References


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

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Sheela Chacko & Nanibala Immanuel  
Spicer Memorial College, Poona, India

**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 baseline 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 & Haggarty 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>
<thead>
<tr>
<th>Students’ Conceptions</th>
<th>Students’ Expressions</th>
<th>Frequency (n=31)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Digestion of food (n=18)</strong> By eating food</td>
<td>“They are produced by when we eat it, is going to be digested so this is the way waste is produced”</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>“We eat our food and it goes to the small intestine and digest and it is produced”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>“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.”</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
</tr>
<tr>
<td><strong>Food that is/not digested</strong></td>
<td>“By the food which is not digested”</td>
<td>2</td>
</tr>
<tr>
<td><strong>More food than the body requires</strong></td>
<td>“They are produced when we eat more food that is not required for our body the left over food becomes waste”</td>
<td>2</td>
</tr>
<tr>
<td><strong>In-take of needed food and excretion of the left over food</strong></td>
<td>“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”</td>
<td>3</td>
</tr>
<tr>
<td><strong>When we eat the food the good products are taken and bad are excreted (1)</strong></td>
<td>“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.”</td>
<td>1</td>
</tr>
<tr>
<td><strong>The intake of vitamins</strong></td>
<td>“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.”</td>
<td>1</td>
</tr>
<tr>
<td><strong>Kidneys produce waste products</strong></td>
<td>“With the help of our kidneys”</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>“Kidneys help.”</td>
<td></td>
</tr>
<tr>
<td><strong>Digestion of food and urinary ducts</strong></td>
<td>“They are produced because of digestion takes place in our body and produced in urinary ducts”</td>
<td>1</td>
</tr>
<tr>
<td><strong>Miscellaneous</strong></td>
<td>“When we eat food or water the stomach is full and it produce gases and we go toilet”</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>“They are produced by excreting our”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>“They are produced by bacterial”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>“By eating, the waste products will come out. by eating they are produced”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>“They are produced from smallest particle from the body”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>“It goes in and then it mixes and it is removed.”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>“They are not needed so they are product”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>“Some harmful effect”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>“The waste products is done something and excreted”</td>
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</table>
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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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

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

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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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large private school system in Karachi. I have named this school the Karachi Model Secondary School (KMSS). 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 bare 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, 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 classroom 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 Delaware; 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 analy-
sis, 8 factors and were identified. The categories were:
1) Managing and Administering Science Instruction, 2)
Diagnosing and Evaluating Learners for Science In-
struction, 3) Science Teacher Self Improvement, 4) 
Subject matter knowledge, 5) Administering labora-
tory 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 particu-
lar needs arise due to the recent Malaysian govern-
ment policy on the teaching of Science and Mathemat-
ics. 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 de-
velop teachers’ own competency, both in English and 
ICT, as a response to the current development. How-
ever, 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 fur-
ther supported by another prominent needs indicated 
by the science teachers, which are related to the need 
for self-improvement. The needs revolve around con-
cerns such as ‘to improve professionalism through in-
service courses’, ‘to gain knowledge on innovative sci-
ence teaching’ and ‘to enhance one’s thinking skills’. 
It appears that over the years, Malaysian science teach-
ers needs seem to still focus on the improvement of 
one’self. 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 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 motion.
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. In spite of applying so much force the lid of the tin is not opening
4. 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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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”.

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.

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 de-
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.

**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.
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.

References


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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 its 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.

References

Students’ Alternative Conceptions in Pressure, Heat and Temperature
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Homi Bhabha Centre for Science Education, TIFR, Mumbai, India

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 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.
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

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

References
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.)

References
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 its 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 acidic, basic, 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. 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,

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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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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.]

References
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 focusing 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 re-
fection, autonomy and networking are subsequently re-
ined 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, cat-
egorized and compared. Common features and differ-
ences 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 ex-
periments about electricity for their students. They and a
sample of their students were interviewed about the sus-
tainable 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 fur-
ther 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 sys-
tem 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 re-
stricted to their classroom practice. They are increas-
ingly 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:

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<td>Innovative teaching and learning methods</td>
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<td>Knowledge of current developments in science and science education</td>
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<td>Provision of adequate learning conditions (resources, atmosphere)</td>
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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 longstanding 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, & Buttrum, 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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