NOTE TO USERS

Conversations, connections and critical thinking: Collaborative action research with women science teachers in Hyderabad, India.

By

Anjali Anna Abraham

Department of Integrated Studies in Education
McGill University, Montreal, Canada
October 2004

A thesis submitted to McGill University in partial fulfillment of the requirements for the degree of Master of Arts (Curriculum),

Your file Votre référence
ISBN: 0-494-12692-2
Our file Notre référence
ISBN: 0-494-12692-2

ABSTRACT

The National Policies of Education in India have recognized the need for teacher professional development. However, science teachers continue to look for innovative methods to improve teaching. Through collaborative action research with four science teachers at a girls' school in Hyderabad, India, the study explored conditions that enhance or inhibit the implementation of constructivist instructional methods. Data were collected through interviews, reflective memos, research journal, collages and found poetry. The study found that teacher background and experience, teachers' views on science education and the school environment played a role in teacher development. The use of constructivist instructional strategies affected teachers' views on science education. The teachers felt that acknowledging students' preconceptions helped them grasp scientific concepts easily. Also, constructivist methods made teaching more enjoyable and less burdensome. Teacher education institutes should consider creating collaborative networks between teachers and researchers and apply constructivist approaches to teacher education and development.

RÉSUMÉ

En Inde, les politiques nationales en Éducation reconnaissent la nécessité du développement professionnel des enseignants. Toutefois, les enseignants en sciences continuent à rechercher des moyens innovateurs pour améliorer l'enseignement. Grâce à une recherche active et collaborative avec quatre enseignants en sciences d'une école de filles à Hyderabad en Inde, l'étude a démontré les enjeux qui accroissent ou restreignent l'implantation de moyens constructivistes en enseignement. Les données ont été recueillies par le biais d'entrevues, de mémos réflectifs, d'articles scientifiques, de collages, et de «found poetry». L'étude a révélé que la formation et l'expérience des enseignants ainsi que leurs idées sur l'éducation des sciences et l'environnement scolaire jouent un rôle dans le développement professionnel des enseignants. L'utilisation de stratégies d'enseignement constructivistes a influencé les idées des enseignants sur l'éducation des sciences. Principalement, les enseignants estiment que reconnaître les idées préconçues des élèves par rapport aux sciences aident les élèves à assimiler plus facilement les concepts scientifiques. De plus, les méthodes constructivistes rendent l'enseignement plus agréable et moins laborieux. Les institutions d'éducation devraient donc songer à la création de réseaux collaboratifs entre enseignants et chercheurs afin d'appliquer des approches constructivistes dans la formation et le développement professionnel des enseignants.

ACKNOWLEDGEMENTS

There are numerous individuals whose generosity and support have been an essential ingredient in the completion of this monograph.

I would like to thank my parents, my role models, Nargis and Jaya Abraham for their love and encouragement. It has been my sustenance, my source of strength. Mama, thank you for reading and editing my work and teaching me most of what I know about teaching and learning. Papa, thank you for always being enthusiastic about my work and always finding a way to get me through my technical difficulties, despite being 4800 kilometers away!

I am immensely grateful for the support of my supervisor Dr. Kate Le Maistre. Kate, I appreciate your patience, encouragement and thoughtful guidance. Thank you for modeling and directing me in the ways of the rigors and responsibilities of research.

I would like to thank my grandfather, Diler Ahmad Shah, for his support and care while I lived in India. Nana, thank you for demonstrating the meaning of social service, commitment and honest work. I would like to thank my sister, Tarunika Abraham, for her love and companionship. Tara, thank you for patiently listening to me as I talked out this project from start to finish.

This monograph has largely been made possible because of the work done by the teachers at Princess Esin Girls' High School (PEGHS). I am deeply indebted to Sana, Seema, Shanthi and Meena who participated in the research project and shared their friendship and experience with me. I am extremely thankful for the support of Mrs. Nazeer, the school Director. This project would not have been born if it were not for her willingness to explore the possibilities of a cross-cultural project in teacher development. My experience would not have been complete without the connections made with the students and the rest of the teaching and non-teaching staff at PEGHS.

To the members of the McGill Center for Research and Teaching on Women, particularly Dr. Shree Mulay, thank you for supporting this research project both financially, through the Margaret Gillett Graduate Research Award, and intellectually, through the knowledge imparted through various conversations, seminar talks and courses. To my friends, my soul sisters, Sara, Esther, Allison and Lisa, thank you for believing in this project and encouraging me to persist towards completion.

It is through conversations and connections with these individuals that I have been supported and challenged to critically examine lived educational experiences; on these wings my mind has been able to journey across the terrains of educational research and practice. The experiences recorded in this report are therefore representative of this collaborative effort, although reflected through my own partial perspective, as co-participant in the project.

TABLE OF CONTENTS

CHAPTER 4: PRESENTATION OF RESULTS

CHAPTER 5: DISCUSSION OF RESULTS

CHAPTER 6: LIMITATIONS AND IMPLICATIONS FOR FUTURE RESEARCH

APPENDICES

CHAPTER 1: INTRODUCTION

Prelude 1: *So here I am, at the beginning of this next stage. The beginning of the end of a program that has resulted in a shift in thinking...something like the Kuhnian "paradigm-shift". The journey so far between an earlier, more scientifically based, frame of reference to a somewhat social-science/humanity based paradigm, has me wondering (wandering?) about the absence of a destination (for me at least) at either extreme. I linger in the space between ... a good place for now. It's a space in which I can (I must) begin this piece that will tell the story of not just this recent excursion of mine, but will hopefully include that of a country, a city and a school...*

In summer 2002, prior to commencing my MA, I had the opportunity to visit India. While I was there, I spoke with teachers, administrators, NGO coordinators and teacher educators who shared their thoughts about education in India. A common theme emerged in conversations with them: the need to look for effective instructional methods. Experts (Kishore, 2000; Maheshwari, n.d.a, n.d.b; Sreelekha & Nayar, 1998) have described the current classroom situation in India as one that is based on traditional teaching methods. They identify the need to diversify teaching methods in keeping with the growth in information and technology while recognizing the variety of cognitive abilities of students. These conversations and readings motivated the present project.

The purpose of this project was to design, implement and evaluate constructivist instructional methods through collaborative work. The research study sought to identify the relationship between participation in the Teacher Instructional Strategies Development (TISD) group and the implementation of new instructional strategies (IS) in a single-sex girls' classroom in Hyderabad, India.

Purpose of the research study

I learnt about Princess Esin Girls' High School (PEGHS) through my grandfather. He had volunteered his time as financial advisor to the Princess Esin Women's Education Center (PEWEC) that the school was affiliated with. The PEWEC was funded by the Nizamia Hyderabad Women's Association Trust (NHWAT) set up through resources donated by

the once princely rulers (Nizams) of Hyderabad. The building and grounds on which the school is situated, Purani Haveli, had been the women's quarters for members of the 6th Nizam's household. It is an appropriate location for an organization seeking to further the cause of women's and girl-child education.

PEGHS was one of the schools I had visited during the summer of 2002. I had been impressed by the school Director, Mrs. Nazeer's, vision for the school and her account of how she had nurtured it from its small beginnings in 1991. Her sincere desire to empower the girls in the community and her high expectations of the teachers and students was evident not only in the success of the school but also in the nature and variety of the curricular, extra-curricular and leadership opportunities available. The school, which began as a kindergarten school in 1992 with 150 girls, has grown into a high school that serves a student population of over 1100 girls. Most of the students and teachers lived in the Old City of Hyderabad, the twin city to Secunderabad, where I spent my childhood years. Given the desire by Indian educators to move away from traditional teaching methods (Kishore, 2000; Maheshwari, n.d.a, n.d.b; Sreelekha & Nayar, 1998) and my own struggles and dilemmas as an early career science teacher in Canada, I was eager to learn about the means by which Indian teachers negotiated pedagogical change in their complex school environment. I approached PEGHS in January 2003 with my proposal to work with a small group of women science teachers on a professional development project to use constructivist methods in their teaching. The project was to take place between the months of August 2003 and October 2003.

In this project, the instructional strategies used by the participants were based on the educational ideology of constructivism (Bybee, 1993; Driver, 1983; Grennon-Brooks & Brooks, 1993). The format for the Teacher Instructional Strategies Development (TISD) group was based on the ideologies of mentorship and situated learning (Jaworski & Watson, 1994; Lave & Wenger, 1991). The research methodology followed that of collaborative action research (Lin, 2002). An anticipated result of this project was to identify conditions facilitating teacher professional development.

Research Questions

This project sought to address the following primary question by answering the listed secondary questions:

Primary Question

What conditions affect the implementation of constructivist instructional strategies (IS) by women science teachers at a girls' school in India?

Secondary Questions

1) To what extent is the implementation of constructivist instructional strategies at a girls' school in India affected by:
    a) teachers' educational background and experience?
    b) teachers' views on science, science teaching and students?
    c) school environment, including opportunity for collegial interaction?
2) To what extent does the use of constructivist strategies affect women teachers' attitudes towards science education?

The educational framework of a region, i.e., curriculum, pedagogy and policy, is influenced by its history and culture. This research study concentrates on three areas: 1) girl-child science education, 2) constructivism and 3) teacher professional development in the city of Hyderabad, India. In this light it would be useful to provide a description of the history of education in India, with a particular focus on women and girl-child education and more recently (in the post-colonial era, after 1947) the attention paid to science education and teacher education. A brief account is provided in the following section. For a detailed description please refer to Appendix A.

History of education in India

The different forms of education over the centuries has influenced the contemporary educational context in India. In relation to women and girls we see there has been a varying amount of attention over the different periods of history. Policies recognizing the need for teacher training and science education were framed and implemented by the Indian Ministry of Education, during the post-colonial period.

Pre-colonial Era (c.1500 BC – 1756 AD)

In the ancient period (c.1500 BC – 700 AD) a number of women from the upper castes participated were educated in the arts and sciences. Women had property rights and they studied religion, poetry, music, dance and defense. Later however, women became increasingly marginalized, with the institution of Manu's code in the late Vedic period (c.800 BC – 700 AD). Manu's code restricted women to the domestic sphere and took away their marital and property rights. Social customs such as sati, dowry and child marriage, that directly affected women and girls, became a part of the culture. This oppressive trend continued into the medieval period (1026 AD – 1756 AD) when practices such as purdah, royal harems, polygamy and child marriage became widespread. Although the medieval period is considered the "dark period in women's history", there are accounts of the existence of women poets, orators, musicians, accountants and warriors (Chaudhary, 1995; Pillai & Rajeswari, 1988).

The indigenous education system consisted of village schools known as *gurukuls* or *agraharas* (in South India). Teachers known as *gurus* provided instruction in religious texts such as the Vedas and vedantas, grammar, philosophy and languages. Vocational education, such as carpentry, metalworks and farming, was also provided. These schools were primarily attended by male students of the upper castes (Kamat, 2003a).

Colonial Era (1756 AD – 1947 AD)

During the British rule, through efforts of Christian missionaries, members of the British government and Indian social activists, there was a move to abolish the social practices of the caste system, child marriage, widowhood, sati, female infanticide and purdah which affected women, scheduled castes and scheduled tribes (Pillai & Rajeswari, 1988). To improve the condition of these traditionally marginalized groups through education, schools were set up for them (Srivatsava, 1998). A new form of schooling was established in the early nineteenth century, based on the European system replacing the indigenous school system. To prepare teachers to work in this new system, teacher training was proposed, and in 1882, the Indian Education Commission introduced separate teacher education programs to prepare teachers for the elementary and secondary levels (Maheshwari, n.d.c).

School curriculum was a terrain on which two ideological battles were fought. One conflict was posed by the nationalists, who felt that the curriculum reflected the knowledge and objectives of the colonists. Gandhi's Wardha scheme called for a boycott of the colonial system, and as a result there was an increase in attendance at national schools and colleges set up in different parts of the country (Sankhdher, 1998).The other conflict was between the newly formed middle class that had been educated in the colonial system and the proponents of popular education. The upper classes, fearing a loss of social status due to upward mobility of newly educated groups, resisted proposals by the British government for popular education and education in vernacular languages (Bara, 1998; Bhokta, 1998). Tagore's educational ideology drew upon Indian and European traditions and knowledge. Schools and colleges (Shanthi Niketan and Vishwa Bharathi University) based on his ideology of education in local languages, arts and sciences, gained a following, but were not implemented on a wider scale by either the colonial or the newly formed Indian government (Das Gupta, 1998).

Post-colonial Era (1947 – present day)

After independence on August 15th, 1947, the Government of India framed three National Policies on Education (1968, 1979 & 1986). These policies recognized the need to improve the education of women. The policies also recognized that to retain girls in schools an adequate number of female teachers would need to be trained. Teacher training has been one of the goals of the National Council for Teacher Education (NCTE) established in 1995. Along with the NCTE, the National Council for Education, Research and Training (NCERT), the State Council for Education, Research and Training (SCERT) and local Colleges of Education have undertaken a number of training programs for teachers. Training has been offered on the use of equipment and resources to improve teaching and learning in primary schools. Workshops on the use of computer technology and preparation for government examinations have been offered to secondary school teachers. Colleges of education are required to conduct annual training sessions for teachers on a variety of areas in education as laid out by the NCTE (Maheshwari, n.d.c).

While these initiatives are indicative of the progress made, there remains the issue of reduced participation of women and girls. The United Nations Development Program (UNDP) reports that the adult literacy rate in 2001 was 58% and the youth literacy rate was 73.3%, with females attaining only 67% of the male adult rate and 82% of the male youth rate (UNDP, 2003). There is a decrease in participation of girls as one moves from primary, to secondary, to tertiary forms of schooling (refer to Appendix A for persistence ratios of girls). Teachers participating in the training programs continue to search for ways to improve their classroom practice. Ongoing professional development and training should ideally be a part of effective practice. While opportunities need to be made available, a greater understanding of how teachers adopt new instructional methods in their classrooms would be helpful. The purpose of this research study was to attempt to move in this direction.

Prelude 2: *It's taken some time to absorb and longer to write about the educational history of India ...the fact that I was unaware of how far back the records go, particularly with regards to the presence of women in educational circles, is indicative of the necessity to have done the groundwork. I wonder about the myth of unidirectional, single dimensional progress; that humanity moves forward in thinking, creating and being ...possibly my personal (mistaken) perception. I understand now "if we don't study history, we are destined to repeat it". How does this project seek to spring from such foundations ...solid in policy, liquid in programs, vapor in implementation & evaluation?*

This thesis report attempts to provide answers to the research questions. In Chapter 2 the literature on girl-child science education, the constructivist ideology and teacher development through mentoring and communities of practice is explored. These readings provided the foundation for the Teacher Instructional Strategies Development (TISD) project conducted in Hyderabad, India. Chapter 3 provides a rationale for choosing the Qualitative Research methodology and the method of Collaborative Action Research. It also provides a description of the research procedure and process of analysis. Chapter 4 contains the results and analysis of the interviews, collages and reflective memos collected as data texts of the field experiences. Chapter 5 consists of a discussion of the results and provides a synopsis of the findings. The final Chapter 6 consists of personal reflections on the research process and implications for further research.

CHAPTER 2: REVIEW OF LITERATURE

Interlude 1: *Scientific research requires one to draw upon certain established theories as the building blocks for one's analysis and argument. Kuhn's book "The structure of scientific revolutions" provides an exhaustive description on scientific culture and practice. He describes the long drawn- out process through which theories are established. Accordingly it would be fit to acknowledge these building blocks, from multi-dimensional space, as we proceed to construct structures through interpretation and experimentation that reach into our own personal dimension.*

The three broad areas which this study covers are 1) girl-child science education, 2) constructivism and 3) teacher professional development. The previous chapter dealt with the history of education leading to the contemporary scene in India. This chapter presents a description of the theories and research studies in each of the three broad areas on which the study was designed. An understanding of women and girl-child education, in India and the world, was useful for the work conducted in a girls' school with women science teachers. The literature on constructivist science served as the foundation for the instructional strategies used by the Teacher Instructional Strategies Development (TISD) group. The function of the TISD group and the roles of the researcher and the participants drew upon studies on teacher development and the literature on mentoring and communities of practice.

Girl-child science education

> How could the rational use of land, the economic management of water, the protection of forests, the preservation of bio-diversity be envisaged if the women who play a vital rôle in each of these sectors do not have sufficient schooling and information to understand what is at risk and how to adapt their behavior to new situations? How can sanitary conditions be improved, malnutrition be fought and new birth control policies be instituted if women are unable to master the new situations they must face? (Claire, 1995, p.4)

Interlude 2: *Will it ever be possible to achieve a perfect balance of representation? I realize that ultimately it's about the availability of choice and access to options, about whose knowledge is valued and whose standards form frameworks within which we live, work and play ...in order that all individuals, woman or man, adult or child, rural, urban or tribal, black or white may live fulfilling lives.*

Why does the number of female students in the science classroom not reflect the gender ratio in the general population? In my classroom in Canada, the number of girls enrolling in my senior physics classes year after year was miniscule, even though female students often demonstrated stellar aptitudes and performances in this class. In an internet conversation in early 2003, Clara (pseudonym used) shared why she had chosen to study computer engineering. Clara said it was not until she was in her final year in high school that she realized she would choose a science stream for her future. She mentioned that she chose this field as much out of interest as out of the career possibilities in the field. Clara stated that the ratio of women to men in her computer engineering department was still just one in ten. In preparing the report for the 1995 Beijing Conference on Women, Claude Musnil (1995) presented the following picture: between 1985 and 1991 there was an increase in the percentages of both male and female engineers, with a slightly greater increase among women (22.1%) compared to men (21.7%). Musnil points out that despite this apparent growth, female participation has not exceeded 30% of the total student body in any country. The gender gap in science education is closing – at a snail's pace.

There is an urgent need to encourage girls' participation in scientific communities. To do so, we need to closely understand the various factors at play: gender inequalities in science identities, textbook images and content, student-teacher interactions and role models in science. The first part of this section explores the literature on participation of girls in science and the second part provides some experts' views on women and girl-child education in India.

Girls and science

The process of gender formation and enculturation into social and scientific contexts begins at an early age. Children receive messages, through various social experiences and interactions, about suitable behavior patterns. The messages influence the formation of their identity. Children are known to associate with their appropriate gender label by age three. Through interaction with their parents, children become aware of appropriate

behavior patterns, play preferences and psychological characteristics expected of them (Hudson & Kagan, as cited in Farenga & Joyce, 1999). The transition of males into a scientist's world of autonomy has been explained by Winnicott and Chodorow's theories of connectedness in females and separation in males due to their early interactions with their mothers as child-rearers (Farenga & Joyce, 1999).

Textbook content and images depict the exclusion of women's interests and their contributions to science. Two thirds to three fourths of the illustrations in science textbooks have been found to depict males (Wood, 2000). Besides the explicit images, there are the implicit messages we send through our interactions with students. Teachers, not unlike most social beings, possess stereotypes of masculine and feminine behaviors. Parents and teachers are far more accepting of female students choosing to opt out of the sciences than their male peers (Duru-Bellat, 1995). William Letts (1999) found that past science experiences had a powerful effect on construction of science teaching identities and gendered identities in pre-service teachers. Personal experiences of school science gave rise to gendered images of a detached and impersonal way of knowing in science. Teachers might be able to better address their classroom interactions with both girls and boys, by reflecting on their own conceptions of gender.

Lave & Wenger (as cited in Davis, 2002) state that:

> Several issues must be considered when reflecting on the legitimate participation of individuals within a community, namely a) acquisition of the necessary knowledge, skills, and other resources valued in the community; b) access to the community to enable individuals to acquire their competencies; and c) open, equitable, engaged participation in the community and the power to make decisions and create change. (p.152)

A number of researchers have suggested strategies, with regards to the participation of girls in scientific communities, which address Lave and Wenger's points:

a) To enable a girl to acquire scientific knowledge and skills we need to identify instructional strategies and content that includes girls' interests. Girls need to connect scientific concepts to their daily lives to feel they have understood the concept, whereas boys feel they have understood a concept if it fits into their existing conceptual framework (Stadler, Duit & Benke, 2000). Jeffrey Weld (1999) advocates a Science/Technology/Society (STS) curriculum as a solution to gender and ethnic curricular biases. Girls opt out of physics and computer courses on account of the militarization of physics concepts and few game characters depicted in real-world problem-solving situations with a sense of purpose (Easle, as cited in Farenga & Joyce,1999; Wood, 2000). Girls succeed more when teachers encourage cooperation rather than competition between students (Peterson & Fennema, as cited in Duru-Bellat, 1995). Girls' attitudes towards mathematics are more positive in classes where there are more private exchanges between teacher and student than voluntary public exchanges (Eccles & Blumenfield, as cited in Duru-Bellat, 1995).

b) In order to provide access to the scientific community girls need to acquire scientific competencies. Wood (2000) suggests inviting female members of the community working in science related fields into classrooms to discuss their careers. Parents can cultivate comfort, curiosity and competence in science, what they refer to as "science sensibilities", in their daughters just as much as they seem to be doing with their sons through books, television, museums, zoos, hobbies, clubs, web sites and family vacations (Farenga & Joyce, 1999). Long term experiences with science favors girls' decision pursue the study of science (Duru-Bellat, 1995).

c) For women to be able to make decisions and create change they must be encouraged to persist towards leadership positions. Only between 1-5% of the leadership and decision-making positions in scientific and technological fields are held by women (Claire, 1995). By understanding the conditions for the participation of girls in science and technology, giving them shared control over policies and practices that affect their lives, and involving them in making decisions and developing plans for learning and careers, they

will be more likely to believe in their abilities and persevere in their education and careers (Nicholson & Fredericks, as cited in Davis, 2002). Inadequate representation of one half of humanity in professions that guide our futures should be addressed by working towards equitable and sustainable educational development. In India the participation of girls in education has been studied with intentions towards altering educational policy and practice. A brief overview of girl-child education in India is provided in the following section.

Girl-child education in India

The three National Policies on Education have recognized that attention has been given to women's and girl child education. The National Council for Women's Education in 1961 proposed that no differentiation was to be made in the curricula for boys and girls at the primary and middle school stages. As Pillai & Rajeswari (1988) state, an important value to be built on through textbooks is to enable each sex to develop a proper respect towards the other. At the secondary stage it was proposed that diversified curricula should meet the aptitudes and capacities of all adolescents. If properly implemented, this program was to provide for the special needs of girls.

The National Commission on Teachers I (1983-85) recommended that a) scholarships be instituted for women with 7 to 8 years of schooling who would be willing to serve as teachers in rural elementary schools, and b) provision be made for the construction of modest quarters for women teachers and for the creation of anganwadis and balwadis (pre-primary schools and creches). Although progress has been made in the area of girl-child education, a lot remains to be done to increase the enrollment of girls and encourage their retention in schools (Gupta & Hussain, 1998). Though among the small section of women in the middle and upper socio-economic groups enrollment is high and their participation in the labor force has greatly increased, Chaudhary (1995) states that overall enrollment of girls remains low along with a high drop-out rate. This is on account of the fact that if children are to be withdrawn from schools for socio-economic reasons, usually it is the girl child that is first removed. Further, the low marriage age of girls which often

results in them becoming mothers at an early age, the continuation of purdah and the irrelevancy of education are factors contributing to the lower participation of girls in schools (Chaudhary, 1995).

Therefore, experts in different parts of the world have addressed the low participation of girls in science and education. To increase the participation of girls in scientific fields it is necessary to understand how their social and educational experiences influence the formation of their science identities. A number of strategies to include girls in scientific communities have been suggested. Girls are known to need to connect scientific concepts to their daily lives. The constructivist approach to science education acknowledges students' lived experiences in teaching and learning.

Constructivism

> What were ducks in the scientist's world before the revolution are rabbits afterwards. The man who first saw the exterior of the box from above later sees its interior from below...Only after a number of such transformations of vision does the student become an inhabitant of the scientist's world, seeing what the scientist sees and responding as the scientist does. (Kuhn, 1996, p.111)

***Interlude 3**: Science has a large influence on our cognitive structures and the knowledge based, progress-driven world in which we live. The nature of science is predominantly defined by members of a small elite community. In our schools we teach students the culture of this community so that it may perpetuate ...Does the scientific community cater to the interests, needs and purposes of all groups of people and co-inhabitants of our planet? Why do I as a teacher subject my students to this process of enculturation? In whose interest do I do it? How can I ensure that the methods I use are not oppressive but emancipatory?*

My students' questions during my first few years of teaching science directed me towards deconstructing curriculum content. The use of missile launch examples in physics and maximization of profits in mathematics are some of the situations my students drew my attention to. Their questions, while directing me to the problem solving contexts, also made me realize that they brought into the science classroom their own perceptions and understanding of the world in which we live. During my master's coursework I read

about constructivist strategies that enabled me to re-examine my teaching methods and find ways of teaching that acknowledged students' prior knowledge and understanding of scientific concepts.

The first part of this section will examine constructivist ideology. The second part will include an overview of the current state of science education in India.

Constructivism and science

Students bring to the classroom experiences from their social and cultural contexts. These experiences result in knowledge constructions that are at once individual and social. Most educational practices consider students as devoid of the ability to understand topics to be covered, thus leading to instructional methods that aim to deposit relevant concepts into learners' minds. Freire (1972) refers to this as the banking model of education. Constructivism offers an alternative metaphor for education: education as a life-long journey; one where the past experiences determine present interpretations, decisions and future destinations.

"Constructivism is not a theory about teaching. It is a theory about knowledge and learning" (Grennon-Brooks & Brooks, 1993, p.1). Constructivism draws from the fields of philosophy, psychology and anthropology (Grennon-Brooks & Brooks, 1993). Its philosophical roots are evident in the way it defines reality as diverse and changing, and knowledge as an ongoing process of meaning-making. Constructivism encompasses the idea that learning is a mechanism for adaptation to the environment. Anthropologically, it considers human behavior as determined by the social, historical and cultural settings. Socrates, who practiced a dialogic approach to learning and knowledge construction, might be thought of as the earliest proponent of a constructivist notion. More recently, Jean Piaget's theory of stages of cognitive development has formed the foundation upon which constructivist ideology has taken shape (Grennon-Brooks & Brooks, 1993). The constructivist approach differs from the behaviorist approach of Thorndike and Skinner, which considers student performance as response to stimuli under the teacher's control. It

also differs from the inquiry-based approach of Bruner, which proposes that students come to know their world by interacting with it (Ornstein & Hunkins, 1998). Constructivism suggests that by recognizing that students' prior knowledge plays a significant role in the construction of knowledge, a teacher might effectively structure learning situations that value these early understandings of the world.

Constructivist approaches have resulted in a re-evaluation of views on scientific knowledge. Traditional approaches to science consider science knowledge as objective and outside the realm of personal influence. Shapiro (1994) speaks of scientific insight as:

> ... a wholly unique and personal view held by a single individual that has led us to consider "old data" in a new way or has prompted the total reconstruction of an entire way of looking at a field of knowledge. (p. 5)

In the constructivist approach, the personal perspective of a scientist is taken into consideration in the explanation of scientific results. Subjective responses and biases in methodology have extended quantitative scientific methods to include qualitative research methods. Although there might be differences of views on the objectivity of scientific knowledge, two matters upon which scientists and science educators might agree are 1) the pluralism of scientific theories and 2) the influence of the theoretical perspective of the observer on the objectivity of scientific observations (Driver, 1983). The philosophical view of scientific knowledge as absolute rather than tentative has also been discarded. As research and technology advance so does our ability to add to the construction of a scientific base of knowledge.

Scientific literacy is a widely accepted goal of science education. The outcomes educators work towards include: everyday coping ability, understanding the structures of science, making science-technology decisions, developing scientific skill and providing correct explanations of scientific phenomena (Bybee, 1997). Conceptual change in science takes place over a period of time, as is the case during scientific revolutions (Kuhn, 1996). Students' preconceptions of scientific phenomena are resistant to change because these preconceptions have worked well for their understanding of the world.

Unless a new idea or concept can be judged by them as adequate or reliable, it will be rejected (Driver, 1983). Teachers are called upon to recognize the cultural clash between students' home culture and the culture of school science. Teachers need to understand their role as culture brokers, to enable students to negotiate between the two cultures (Aikenhead, 2001). Constructivist instructional methods are suited to such cross-cultural border crossings. Bybee's 5E (Engage, Explore, Explain, Elaborate & Evaluate) model is based on a constructivist approach. He suggests that by "using this [constructivist] approach, students redefine, reorganize, elaborate, and change their initial concepts through self-reflection and interaction with their peers and their environment."(1997, p.176). Grennon-Brooks and Brooks (1993) summarize the objectives of constructivist science when they say that constructivist educators must strive to:

> 1) Free students from the dreariness of fact-driven curricula and allow them to focus on large ideas
> 2) Place in students' hands the exhilarating power to follow trails of interest, to make connections, to reformulate ideas, and to reach unique conclusions
> 3) Share with students the important message that the world is a complex place in which multiple perspectives exist and truth is often a matter of interpretation
> 4) Acknowledge that learning, and the process of assessing learning, are, at best, elusive and messy endeavors that are not easily managed. (p.22)

Constructivist science seeks to situate scientific concepts in the daily lives of students while exposing them to multiple worldviews. These objectives are relevant for both local and global participation. Indian educators are seeking to move away from traditional teaching methods. The next section examines some strategies proposed by them that encompass the objectives of a constructivist approach to science education.

Science education in India

The National Policies on Education state that science education is necessary for the development of a liberal and progressive attitude in an individual as well as for the industrial and economic progress of the country. However, there appears to be a gap between what has been proposed and what gets implemented in the science classroom. Education is predominantly viewed as a passport to employment, as it is in other parts of

the world. This view has produced the "backwash effect" where only what is tested is then taught on account of the stiff competition for entrance into professional programs. Students begin preparing for these exams both in school and at out of school tutorials from the grade 10 level. "The trauma of learning" begins at an early age. Children from the age of 4 are coached for admissions into schools in urban areas and in most cases the form of learning that takes place is rote memorization (Maheshwari, n.d.a). Science instruction, available resources, and textbooks are not in conjunction with the child's cognitive development (Kishore, 2000).

To improve science education, educators must distinguish between information and knowledge and realize the need to convert information into knowledge. This would also entail a shift from a focus on rote-memorization of facts to teaching students how to access, classify and process information (Maheshwari, n.d.a). Some of the strategies suggested are project work, concept attainment and lessons based on and applied to real life situations (Kishore, 2000; Maheshwari, n.d.a; Sreelekha & Nayar, 1998). A constructivist instructional approach recognizing that students construct their conceptual understanding in the contexts of their daily lives has been recommended along with the need to teach students how to be life-long learners (Maheshwari, n.d.a). As a single approach cannot satisfactorily achieve all the instructional objectives, teachers need to employ various strategies that would enable students to learn and apply scientific concepts (Sreelekha & Nayar, 1998).

A number of Indian educators have suggested strategies for change in science education. They call for a move away from traditional teacher-centered instruction to student-centered approaches. Teachers, as facilitators for the change process, need to be given training in programs for reform.

Teacher professional development

> It sounds ideal, but teaching will not become a learning profession until a vast majority of its members become (in my terms) change agents capable of working on their own sense of purpose through inquiry, competence building and collaboration. (Fullan, 1993, p. 127)

Interlude 4: *Experts establish the need to study and support teachers to realize educational change. What do teachers perceive of professional development programs? How have teachers (from different parts of the world) rated these programs in meeting the educational needs of the students in their science classrooms? What are the educational beliefs that guide their participation in such programs ...Until quite recently, the conceptual growth of teachers was something I hadn't given much thought to. It seems apparent now that, before establishing constructivist approaches for students, there is much to gain from an understanding of teachers as learners.*

As a beginning teacher, I was fortunate to have participated in a workplace community whose members mentored me either consciously or unconsciously. Their willingness to share ideas and resources, answer questions, ask questions, take an interest, participate in projects, model teaching strategies and suggest organization techniques were instrumental in getting me through my first few teaching years. Over the next few years, the existence of an environment within which we could discuss problems, share experiences and work out strategies further built upon my earlier pedagogical knowledge, skills and experiences. My master's coursework on mentoring made me recognize the value of these early experiences.

The first part of this section will survey the literature on mentoring and communities of practice. This will be followed by a review of studies on teacher in-service in constructivist science instruction. The final part of this section deals with teacher education and in-service programs in India.

Teacher development

Seventy percent of what people know about their jobs they learn informally from the people they work with (Dobbs, 2000). Thus, mentoring as a form of "situated learning"

for both the mentor and the mentee is located in a social context (Lave &Wenger, 1991). Dr. Le Maistre commented, at a student group meeting in December 2003, that teacher professional development needed to be "on-site, on-demand and on-going". Teachers work at the grassroots of educational change. Making the teacher in the classroom the locus of professional development follows from their familiarity with classroom situations. Dennis Thiessen (1992) emphasizes that, "...Teachers should develop themselves. It should be less a matter of determining what to do 'to' them or 'on their behalf', and more a matter of teachers inventing what to do 'with' others or 'by themselves'." (p.86). Mentoring is the activity that practitioners engage in to provide support for newcomers and to each other in order to enhance their personal practice. It is not only a method of enculturation of newcomers into a profession but involves the on-going professional development of the practitioners. Jaworski and Watson (1994) extend the idea of mentoring by considering processes of co-mentoring and inner mentoring. Co-mentoring involves colleagues talking and questioning each others' practice causing a "forced awareness of issues of concern ... [and creating a] reflective situation from which some form of action results" (p.134). Inner mentoring is similar to an action research approach where the teacher tries out new ideas, observes and reflects on what happens and makes changes for the future. Through reflective practice, teachers "unpack their own work", examine the pieces and re-pack, thus becoming better suited for future practice.

Conceptual change affecting pedagogical practice is similar to the process of change for student learning as described by constructivist theory. The process of attitudinal change takes a long time. Programs of long duration centered at the location of effective change are necessary for successful pedagogical change (Adey, 2002). The intuitive behavior of experienced practitioners prompts them to act effectively in the complex social environment of their classroom (Adey, 2002; Schön, 1983). By reflecting on problematic situations and articulating the means through which they negotiate these situations, teachers can work with their colleagues to find answers to school-based issues. When practitioners co-mentor each other, they play the role of the expert coach who holds up the mirror and tilts it in various directions, enabling them to reflect on their practice and

gain self-awareness. Mentors who do this perform three distinct functions: they support, challenge and provide vision (Daloz, 1999).

We form our identities through participation in diverse communities. In some we exist peripherally, in some more fully and others we aspire to join. A community of practice is constructed through some commonality of purpose and values. Lave and Wenger (1991) provide the following characteristics for a community of practice: there is a "de-centering" of the notion of mastery and pedagogy, where the members share a common understanding of their practice, its meaning in their lives and that of their communities; they possess diverse interests, viewpoints and contributions and there occurs a negotiation and re-negotiation of meaning and identity. Communities have a certain culture that its members share in. The teaching culture is defined through its cultural content and form. The content refers to the attitudes, beliefs, values and the ways of life that the members hold in common. The form describes the relationships between the various members. These could be individualized, collaborative, balkanized or contrived collegiality (Hargreaves, 1997). While some relationships promote learning and growth, in others learning could be distorted. Some problematic scenarios could result when the "master", the leader-teacher or administrator, is too distant or the object of too much respect, when access to artifacts of the community is limited because of control and selection or because of tensions that exist between the old-timers and newcomers in their perceptions of the existing practice (Lave & Wenger, 1991). At times, learning could lead to the perpetuation of negative practices which the community of practice is trying to eliminate (Fenwick, 2001). The intricacies of practice vary across regions and schools. It is important to understand the culture of a school community to effectively institute a program for professional development.

A variety of personal and professional factors contribute to the adoption of new instructional methods by science teachers. Some of the personal factors are teachers' beliefs, attitudes and teaching experience. Teachers' positive attitudes towards science have a significant influence on their students' achievements (Ediger, 2001). Teachers' attitudes towards their subjects are transmitted to their students through their instructional

approaches (MacKenzie, 2001). It is important to account for the educational beliefs of teachers. Haney and McArthur (2002) state that, "Excluding teacher beliefs from any teacher training experience is tantamount to ignoring the importance of prior knowledge in student learning" (p.79). If their beliefs are ignored, teachers experience frustration and constructivist reform methods are not effective (Haney & McArthur, 2002). Teaching is a way of being. There is the need to understand teachers in their social contexts and to work with them in these settings to implement constructivist methods (Feldman, 2002). Feldman (2002) says that:

> ... For teacher educators (pre- or in-service) to act in ways that will evoke change in teachers, they will need to work within the horizons of their educational situations, to shift those horizons in ways that result in a shift in the horizons of the teachers with which they are working. This suggests that a relationship needs to be developed between teacher educators and teachers that is supportive and authentic. (p. 1052)

Teaching experience played a significant role in teachers' attitudes towards constructivist teaching methods (Damnjanovic, 1999). While lengthier teaching experience may relate to receptiveness to professional development, this is true only for those teachers who have the desire to change and improve their practice. At the opposite end of the spectrum, lengthier teaching experiences also result in a reluctance to change and adopt new methods. Entrenched practice will be difficult to change without a great deal of additional effort. At the same time, an increase in student interest and success brings about a change in perception of teachers on the value of open-ended inquiry in science (Marlow & Stevens, 1999).

A number of external conditions make it difficult for teachers to use constructivist methods. The lack of time to use an open-ended constructivist approach, alternative curriculum objectives, large class sizes, lack of equipment and resources, absence of release time and the pressure of examinations are a few factors that present difficulties for the teachers (Chang, 1998; Ramos, 1999). Certain forms of professional development have met with more success than others. Through mentorship and scaffolding by researcher and leader-teachers, teachers are more willing to persist with the use of new

instructional methods (Chang, 1998). School-based teacher development programs have been found to be effective. Some other factors that enhanced the use of these methods were: a general move by the Ministry of Education to recognize the relevance of constructivist approaches, emphasis of their use in recently released textbooks, support by the school principal, participation and mentoring of teachers who had used the strategies successfully in their classrooms in the past, close contact and support of members of the research team and collaboration and support of peer teachers (Wang et al., 1999). Educators in India encounter similar issues with regards to teacher education and development. Some of these issues will be addressed in the following section.

Teacher Education in India

In India, the National Policies on Education have pointed to the need for teacher training programs. However, the diversity in the Indian cultural and social context makes it difficult to design and implement large scale teacher training programs. A number of Colleges of Education have been established to cater to the demand for qualified teachers but the physical facilities and resources available need to be improved to ensure effective training programs.

The teacher education system in India has to cater to nearly 4.6 million school teachers. Given the vast regional diversities, cultural pluralities and geographical variations, efforts to indigenize the system have remained to a large extent at the policy level (Panda, 2001; Walia & Rajput, 2003). There is the need for structural changes in the system of teacher education, redefining of the teacher's role within the framework of the school system and education, renewal of the teacher education curriculum, building a teacher education system that views pre-service and in-service learning as a continuum, and strategically shifting institutional arrangement by bringing teacher education to university level (Panda, 2001). Facilities at teacher training institutions are limited and there continues to be a major lack of resources, infrastructure, materials and expertise. With the increase in the number of schools there is a high demand for qualified teachers. In many parts of the country single teacher schools which were to be eliminated by implementation of

Operation Blackboard continue to exist and grow (see Appendix A for details on Operation Blackboard). At the opposite end of the spectrum there has been the commercialization of colleges of education (Walia & Rajput, 2003). In a conversation with Dr. Rhoda David (October 7th, 2003), instructor at Andhra Manila Sabha College of Teacher Education, I learned that in the last decade the number of colleges offering B.Ed. programs in Andhra Pradesh had grown from 5 in 1991-92 to over 20 in 2001-02 and over 200 in 2002-03. While this might be what is needed to cater to the increasing need for teachers, the quality of the programs being offered in a number of these colleges needs further investigation.

Summary

Therefore, various organizations and institutions have recognized the need to address the low participation of women and girls in science. Some of the factors contributing to low participation have been socialization practices at home and at school, classroom interactions between students and teachers, the content of curriculum and the instructional methods used. Through an awareness of these factors, parents, educators and policy makers might be able to work towards altering practices that inhibit the participation of girls in scientific fields. The constructivist ideology promotes educational experiences that are drawn from and connected to the daily experiences of students. Girls are known to learn by making connections between scientific concepts and their lived experiences.

Constructivism as an educational philosophy has gained wide acceptance in a number of educational circles over the last two decades. The scientific worldview involves being able to observe organisms in their environments, to construct and test hypotheses and derive conclusions. What were traditionally considered objective scientific conclusions are no longer seen as being immune to personal biases and assumptions. The nature of science as absolute rather than tentative has also been challenged and overthrown and the social context of science learning has been recognized. Indian educational experts also recognize the need to move away from traditional lecture style approaches and the focus on rote memorization. They identify the need to design a variety of instructional methods

that would include their students' interests and educational goals (Kishore, 2000; Maheshwari, n.d.a; Sreelekha & Nayar, 1998). Educational change in classrooms is possible through teachers who participate in programs for professional development.

There are a number of approaches to teacher professional development: participating in workshops at regular intervals, taking courses at Colleges of Education, school-based programs, action research studies are a few approaches. Mentoring as a form of teacher development is gaining significance in teacher education colleges. Mentoring approaches are situated at the workplace and revolve around the daily social routines of an experienced employee. Such a partnership results in growth in expertise for both the mentor and mentee. Through reflecting on their expertise, mentors and mentees are able to gain a better understanding of their practice. The school functions as a learning community and teachers form a community of practice. Members of such a community share similar knowledge, skills and values while nurturing their own unique identities and strengths. By sharing common goals these community members collaborate to ensure that the well-being and growth of the culture and purpose of the community.

The research study was informed by this literature review on girl-child science education, constructivist science and teacher development. Based on this literature review, the purpose of the research study was established as follows: the need to investigate conditions that would enhance or inhibit the use of constructivist instructional methods by women science teachers at a girls' school in India.

The next chapter will provide a description of the qualitative research methodology and collaborative action research method on which this research study was designed. The rationale for the TISD project along with the method and process of analyses of the field texts gathered will also be described in detail in the following chapter.

CHAPTER 3: METHODOLOGY

Interlude 1: *Progress in the field of genetics and the Human Genome project have shown us not only how biologically similar we are to members of the human species (you and I share ~99% of the same genetic code) but also to species within a particular genus (such as, chimpanzees and bonobos). Despite this, our lived experiences remain so varied. How best can we study each other and our extended families? ... not forgetting the earth which sustains us, the animals with whom we coexist.*

This chapter will begin with a detailed rationale for the methodology of qualitative research and for the method of collaborative action research. The process undertaken to gather qualitative data will be provided in the second part of the chapter. The final part of the chapter will describe the method in which the data texts were analyzed.

Rationale

> The word "understanding" and the particular meaning she attributed to it, is the cornerstone of Barbara McClintock's entire approach to science. For her, the smallest details provided the keys to the larger whole. It was her conviction that the closer her focus, the greater her attention to individual detail to the unique characteristic of a single plant, of a single kernel, of a single organism, the more she could learn about the general principles by which the maize plant as a whole was organized, the better her "feeling for the organism". (Fox-Keller, 1983, p.101)

Interlude 2: *Seeking understanding and/or seeking truth(s) about the human condition. How does one journey from such an anthropological base towards insight on an educational horizon? From physical position in the environment towards mental constructions in relation to knowledge past, present and imagined? From singular objectivity towards multiple subjectivities? These are what remain (for me at least) the dilemmas of qualitative educational research.*

Qualitative Research in the Global South

Qualitative research methods are gaining the attention in educational policy-making circles. The appropriateness of qualitative research methods to address issues on quality

of schooling has been recognized (Crossley & Vulliamy, 1997). The use of qualitative methods has increased in the wake of the 1990 Jomtien Declaration of Education for All.

Qualitative methodology is based on the notion of transcending objectivity. By acknowledging the plurality of perspectives in readings of the world, a stronger objectivity is achieved. It is an inductive process of theory building, where the researcher's interactions with and between the organism and the environment define the knowledge that emerges. Crossley and Vulliamy (1997) draw attention to the appropriateness of qualitative methodology in the Global South in light of "the dangers and dilemmas of international transfer (of educational ideas and research) and the importance of contextual factors in the analysis and development of education"(p.7). Qualitative research is suitable for educational situations in the Global South as it would not only account for the unique and diverse cultural context but also impose fewer financial constraints than a quantitative study that requires a large sample size. It would also garner more political support for "home-grown research priorities" determined by local personnel (Smith, 1997). Qualitative methods enhance research capacity and authenticity in contexts where literacy and numeracy are less prevalent. Bassey (as cited in Crossley & Vulliamy, 1997) uses the terms *disciplinary* versus *pedagogic* to identify two goals of educational research. The anticipated outcomes of qualitative educational research fall into the latter category, lending greater possibilities for educational change.

There are however factors inhibiting such research. Some factors that have restricted the content and type of research conducted in India are: weak relationships between field practitioners, academics and government officials, weak demand from policy makers, access restrictions on choice of subject matter, language of qualitative research, absence of texts dealing with the methodology of qualitative research in southern contexts, conflicting views on the use of time, limited professional awareness among teachers inhibiting the use of action research, nature of the teachers' own education (focusing on replicating rather than manipulating information) and the acceptance of the social, academic, political status quo which is resistant to unconventional research methods. North-south collaborative educational research teams that can draw upon the strengths of

insider and *outsider* researcher perspectives might be a way to overcome some of the these factors (Chokshi & Dyer, 1997). In Pakistan, various stakeholders (academics from the UK and Pakistan, teacher educators, curriculum developers, practitioners) successfully implemented a qualitative research project that sought to evaluate the curriculum of Pakistan's Elementary Colleges of Education (Smith, 1997). Developing locally relevant and appropriate research methods is possible through a qualitative methodology. For example teachers in post-apartheid South Africa, who were empowered to act against an oppressive education system, learned the skills of reflective practice and worked towards instructional change. More recently in South Africa, teacher-researchers used action research to improve their practice while developing an indigenous research process adapted to local conditions and possibilities (Stuart, Morojele & Lefoka, 1997). Though quantitative research methods are predominant in the Global South, there is gradually increasing support for qualitative studies.

Having done all my schooling in India prior to attending university in Canada, I had some knowledge about the educational system, albeit from a student perspective. I was also fluent in the national language Hindi, which is widely spoken in Hyderabad where this research study was conducted. This *insider* knowledge of the local culture was useful in negotiating my research purpose with my *outsider* Canadian teaching experience, with the teachers at Princess Esin Girls' High School. It enabled me to understand the school environment and build relationships with the members of the school community. As a result I was able to use the qualitative research methodology to draw upon the teachers' pedagogical experiences prior to and during the Teacher Instructional Strategies Development (TISD) project.

Collaborative Action Research

Action research involves an examination of pedagogical practice. Reflecting on classroom situations enables the teacher-researcher to understand factors affecting teaching and learning. Working with colleagues on collaborative research projects

enables teachers to co-mentor each other, while synthesizing remedies to school problems. Hobson (1996) describes collaborative action research as,

> ...A prismatic study, particularly when you add all the vantage points and ways of seeing that are brought by the members of the teacher research group....establishing teacher research community groups enables teachers to celebrate their successes with each other, create and re-create ways of helping groups of children learn more effectively, and strengthen the connections teachers have with each other. (p. 93)

I chose to follow a collaborative action research approach because examples from literature indicated it would be a good fit for a study to be conducted with a group of practitioners working towards changing their practice (Chang, 1998; Hobson, 1996; Lin, 2002; Stuart with Morojele & Lefoka, 1997; Wang et. al, 1999). As the idea for the project emanated from issues put forth by Indian teachers, it was only appropriate to involve them as co-participants. Given their experience and expertise in the local setting, the teachers were able to design lessons appropriate for their classrooms. Even though I was born in India, since immigrating to Canada in 1991, the time spent in India between August-October 2003 was the longest period I had been back. I had to keep in mind that since I had never worked in India there would be aspects of the work culture I would not be aware of. I would need to be sensitive to differences (such as time consciousness, respect for persons of authority, appropriateness of clothing) and learn to adapt and work amidst this. The collaborative action research approach helped negotiate these cross-cultural challenges.

Lin (2002) studied elementary science teachers in Taiwan involved in a teacher development group. This collaborative action research study explored factors that influenced pedagogical changes in teachers when introduced to a teaching model based on the constructivist science education. Lin found that three factors that played a crucial role in facilitating a change to pedagogical practice were the intervention curriculum and the leader teacher, personal factors (such as teaching beliefs, content knowledge and autonomy) and contextual factors (such as time, school context and conflicts, examinations). I followed a similar approach; however, I included my role as a co-participant as I planned and implemented lessons with the schoolteachers in Hyderabad.

As a co-participant I found I was able to gain a clear picture of the process of teacher pedagogical change.

Action research involves a reflective process which teachers in India are not familiar with and therefore they approach it with much initial apprehension. Similar apprehensions were found by Stuart, Morojele and Lefoka (1997) who recount the enormous difficulty of training teachers in reflective practice in their collaborative action research project conducted in Lesotho, South Africa. They attribute this to the lack of professional development and self-assessment opportunities. At the same time they attest to the success of this project as observed in the teachers' enthusiasm as they left the workshops. In another report from Taiwan, constraints such as an exam-oriented syllabus, pressure to complete the curriculum, students' demands to be taught in familiar ways and little time for experimentation are mirrored in the situation surrounding collaborative action research projects (Chang, 1998; Lin, 2002; Wang et. al, 1999).

Data Collection

The field texts of the research study were participant interviews conducted at the start of the project, lesson plans and reflective memos written during the project, collages created at the end of the project and the researcher's journal maintained over the course of the project. Each of these texts were useful in gathering information about the participants, their views on science education, the nature of their teaching practice, their relationship with their students and colleagues, and their views about the effectiveness of the Teacher Instructional Strategy Development (TISD) group. A brief rationale for the use of each of these field texts follows.

Interviews *— (refer to Appendix C for a list of the interview questions)*

Interviewing as a form of data collection in qualitative research has been widely used. Some qualitative research studies that have used interviewing are those of Lin (2002), Chang (1998) and Wang et al. (1999) in Taiwan, Smith (1997) in Pakistan and Stuart

with Morojele and Lefoka (1997) in South Africa. North American studies that have used interviewing are those of Feldman (2002), Haney and McArthur (2002) and Marlow and Stevens (1999).

Interviewing allowed me to gather details about the teachers' educational backgrounds, their practice and their views about teaching and learning, in other words to address the research questions. Questions were designed for each of these categories to serve as a guide during the interview. As this was my first individual encounter with the teachers, the interviews gave me the opportunity to begin to understand their individual personalities and for them to gain an understanding of my personality and perspective. The teachers initially were not clear on how the interviews would serve as sources of data. I got the impression that they perceived this as a form of interrogation of their practice. In order to quell some of their fears, a copy of the interview questions was given to them a day in advance (except for the first interview with Shanthi). As the interviews got underway, the teachers became more relaxed and shared their views on science education and their classroom teaching experiences. I transcribed the interviews when I got home from PEGHS each day, and completed these before leaving the field on October 31st. I began analyzing the transcripts when I returned to Canada.

Lesson plans *- (refer to Appendix D for sample copies of lesson plans)*

Once the interviews were completed, the participant teachers and I set up individual schedules to plan and implement constructivist lessons. The lesson plans constructed with the teachers at PEGHS were based on Rodger Bybee's 5E (Engage, Explore, Explain, Elaborate & Evaluate) model. Suggested performance indicators for each of the 5 stages were provided to the teachers (refer to Appendix E for Bybee 5E model rubric). The teachers were given copies of sample lessons which I had used in my classroom in Canada.

Prior to each planning meeting, I met with the teacher to decide on the lesson topic. I was able then to find information and resources on that particular topic. I used the Internet and

my own previous experience as a source for some ideas, but for the most part ideas for the lessons were collaboratively generated over the course of our meeting. During the meeting, we used a lesson plan template that I had designed and used during my first few years of teaching. We stated the topic, objectives, materials and equipment and proceeded to list and describe the various classroom activities to be engaged in for that class. During the implementation of the lesson, I took observation notes and wrote out a reflective memo which I shared with the teacher later that day or the following day. The teachers in turn wrote reflective memos giving me feedback on the planning and implementation process. The lesson plans were useful as future reference for the teachers and me on constructivist science lessons. They served as a record of the professional development outcomes of the project.

Reflective work (researcher journal and reflective memos) *– (refer to Appendix F for the description for the Reflective Process and Appendix G for sample copies of the reflective memos)*

In the initial presentation to the teachers on August 26, I had shared my rationale for reflective work (writing memos and keeping a research journal) based largely on Schön (1983) who stated that practitioners engage in an artistic performance as they attempt to reframe and address problems that are part of their daily practice. When confronted with problematic situations, a practitioner "...shapes the situation in accordance with his initial appreciation of it, the situation 'talks back', and he responds to the situation's back-talk." (Schön, 1983, p. 79). Such conversing with the situation constitutes reflective practice. Through ongoing inquiry, reflection-in-action and reflection-on-action, a practitioner builds up a repertoire of examples, achieving a higher level of professional expertise. William Louden (1992) states that teachers use a combination of forms (introspection, replay and rehearsal, enquiry & spontaneity) while reflecting on situations of various interests (technical, personal, problematic, critical). When a researcher collaborates with the teacher on an action research project, a more authentic understanding of reflection-on-practice and reflection-in-practice is possible (Louden, 1992).

The research journal enabled me to reflect on my experiences in the field. It gave me a space to record my feelings as well as my misgivings on some hard days. It helped me focus my ideas based on what I was experiencing at the school and what the objectives for the project were. It was a place to brainstorm and to look for alternate methods to structure the project based on events such as Sports Day, exams, Dassera holidays and the Ramzaan timetable that affected the progress of field work. It was also where I recorded my classroom observations which formed the basis of my reflective memos to the teachers. Once I returned to Canada, I found the entries useful in drawing upon the essence of my time at PEGHS. Re-reading the entries over the course of the data analysis enabled me to recapitulate details of conversations and interactions with members of the PEGHS community. I have used sections of these entries in chapters 4 and 6.

I used my journal observations to write reflective memos on the constructivist lessons to the teachers. They had been given questions in the TISD group manual description of the Reflective Process to guide their reflective writing. The teachers wrote reflective memos on the lessons, which they gave me. I made copies of the memos I wrote and gave the originals to the respective teachers. I also made copies of the memos the teachers wrote to me. I kept the original teacher memo and gave them a copy. The reflective memos were a useful tool to exchange our thoughts on the implemented lessons. It helped us evaluate the lessons and consider alternative strategies, where necessary, for future lessons. Through successive cycles of what Roth (1998) refers to as "engaging in teaching" and "reflecting on teaching", we hoped to make changes in pedagogical practice that would help create better learning environments.

Collages *- (refer to Appendix H for copies of the collages)*

Art forms, such as collage, poetry, story-telling, painting may be used to reflect on and gain an understanding of personal, social and educational experiences. Diamond and Mullen's (1999) work on arts-based inquiry in teacher development is based on postmodern educational theories. Arts-based representations could serve to filter, organize, and transform experience into the meanings that make up and display our

knowledge (Diamond & Mullen, 1999). Diamond and Mullen (1999) suggest that "effectiveness of arts-based postmodern activity depends on the degree to which it arouses (rather than transmits) particular feelings and images and the degree to which it momentarily captures and provokes experiential learning." (p.24).

At the end of my first meeting with the teachers on August 26 2003, I shared my identity memo in collage form with them. The questions that had guided me in preparing my collage were similar to those in the TISD manual (refer to Appendix F for TISD manual description for the Reflective Process). Over the course of the project, I kept checking to see if the teachers had had the opportunity to work on the collages. I had given them old issues of the National Geographic, which I had used in creating my collage. I had also told the teachers that they were welcome to use images from other magazines of their interest. It was not until my final week with them that they were able to complete and present their collages. The teachers, who had initially been very apprehensive about their abilities to do this, said that once they began working on their collages it was difficult to fit all that they wanted to represent on a single sheet of paper. They had used extra paper to fit all the images they had chosen to describe their beliefs. Collage work enabled a better understanding of the teachers' educational and pedagogical beliefs (Davis & Butler-Kisber, 1999). Having the teachers use images to describe their role as science educators enabled an understanding of how their views affected their practice. The teachers were able to use images to create metaphors for their beliefs, making their emotional responses more intellectual. A parallel purpose of this activity was to understand that just as our beliefs shape our practice, so also our students bring with them beliefs that influence the ways in which they make meaning of their classroom experience.

Procedure

> ...The answer lies in building an ongoing capacity for continued change within the schools, a capacity which acknowledges the importance of the teacher's role in school change and the importance of the teacher's own development as an ongoing feature of that change. Central to that argument lies teacher development within the context of a school. (Wideen, 1992, p.124)

Interlude 3: *Leafing through my agenda, kept from August to November 2003, I recall the scent of frangipani, the flowers that line my grandparents' home in Hyderabad. One has to lean in close to savor the aroma of these flowers. I came to experience the PEGHS community in a (metaphorically) similar way. As I grew closer to the participants, the students and staff members, I learned about their strengths, their struggles and their commitment to quality education. The fragrance still lingers amidst the pages of the field texts ...it has helped me draw on the essence of my time there as I write this piece.*

In the first part of this section on Procedure, a detailed description of the Teacher Instructional Strategies Development (TISD) group will be presented. The rationale and objectives of the TISD group are detailed in Appendix F. The second part of this section will describe the procedure by which various field texts, i.e., interviews, lesson plans, reflective memos, researcher journal and collages, were gathered.

Participants

The participants in the TISD group were four science teachers who taught grades 4 to 10. For the purpose of this report they have been assigned the pseudonyms Meena, Sana, Seema and Shanthi. All four teachers were nominated by the school Director, Mrs. Nazeer to participate in the project, because they had a history of voluntary involvement in activities outside the classroom. Initially five teachers had been nominated. One of them, a first-year teacher, dropped out after the initial presentation. She said that she did not think she would have the time to commit to the project given her young family and the need to get familiar with her regular teaching responsibilities. The remaining four

teachers each had at least a year's teaching experience. A detailed description of each of the participants has been provided in chapter 4.

Intervention – Teacher Instructional Strategies Development (TISD) group

In this study, the principal part of the action research was the implementation of the Teacher Instructional Strategies Development (TISD) group.

Joyce and Showers (1980) identify two purposes to in-service training - to fine tune present skills and to master new teaching strategies. The outcomes of training have different levels of impact. These may be categorized as: awareness, acquisition of concepts or organized knowledge, learning of principals and skills, and the ability to apply those principles and skills in problem-solving activities. The TISD group project attempted to address these levels at each stage of its implementation. Between Monday, August 25, 2003 and Friday, October 31, 2003 the various activities planned for the TISD group were undertaken.

On arrival in Hyderabad I met with Mrs. Nazeer, on August 25, 2003, and gave her a copy of the teacher's manual (refer to Appendix F for the rationale and objectives of the TISD group). The next day (Tuesday, August 26) I met with the five teachers and shared the purpose, objectives, proposed plan and anticipated outcomes of the research project. I had met two of the teachers the year before, whose questions about instructional methods had caused me to return with the research project. The following day (Wednesday, August 27) I met with the teachers individually to set up interview times. Between August 27 - September 3, 2003 I was able to interview the four remaining participants and set up our first lesson planning meeting. Having a better idea of the school timetable at this point, I realized that we had to aim to complete most of the implementation prior to October 9, 2003, the Annual School Sports Day. The school closed October 10-21 for the annual festival of Dassera.

I had initially hoped to conduct group planning meetings with the teachers. The teachers shared that as they rarely had common preparatory time it would work better to meet with them individually to plan lessons. This would enable me to get to know them and their individual practices better. The Sports Day practices, school examinations, Dassera holidays and the altered timetable for the season of Ramzaan were some of the events that occasionally interrupted meeting times. We were able to reschedule meetings to plan and implement between two lessons (with Meena and Shanthi) to three lessons (with Sana and Seema).

When I was not doing classroom observations or in planning meetings with the teachers, I spent my time journaling or writing reflective memos in the school library. The teachers knew they would be able to find me there in case of a change in plans. I also got to know a number of students who frequented the library. Being at the school gave me the opportunity to participate in a variety of school activities. I attended all the staff meetings scheduled during my time there, as well as the Teacher's Day celebrations and guest speaker presentations. I also visited the Andhra Pradesh Pollution Control Board mobile exhibit and participated in the Annual Sports Day as one of the Master of Ceremonies.

I had shared my Identity Memo, in collage form, with the teachers at the beginning of our work together. During the final week of my time at PEGHS, the teachers prepared their own Identity Memos. Seema and Sana worked individually on their collages. Shanthi and Meena worked together on one collage. Both of them had been very hesitant to do this work so I was glad when they offered to do it collaboratively. I was able to videotape the teachers describing their collages on the second last day of the project. My final day at the school, Friday, October 31, was spent saying an emotional goodbye to a school that had welcomed and treated me as one of their own community. Upon my return to Canada I sent a brief report to the school Director on my time spent at PEGHS.

Data Analysis

... Mental gymnastics,
Metaphoric madness,
Mosaiced thoughts, words, feelings and actions,
Meanings made in multi-dimensional space.
- From poem Multi-dimensional space: Qualitative research and constructions of reality, by A. Abraham

***Interlude 4**: So many things said. Gathering and analyzing data helps fill some of the gaps between theories and practice, between existence and understanding ...But much remains, in the quest towards truth(s) that define the complexity of lived experience, in the things left unsaid ...How can one traverse into this elusive dimension? Will the layering of various data texts enable a clearer vision of this hidden space?*

The final part of this chapter explains the process by which the field texts were analyzed. The theoretical basis for the analysis undertaken were Maxwell & Miller's (1992) use of paradigmatic and syntagmatic relationships and the constant comparison method proposed by Maykut & Morehouse (1994). Maykut & Morehouse's (1994) method of constant comparison builds on qualitative analysis theory proposed by Glaser and Strauss (1967). For each inductively determined category, a rule of inclusion is defined by which future data segments are selected. The rules of inclusion describe characteristics of the data segment to be included and contain an initial proposition of the researchers' analysis or "statement of fact" of the particular category. There are two types of relationships between segments of analyzed data. Paradigmatic relationships are based on similarity and syntagmatic relationships are based on contiguity (Maxwell & Miller, 1992). A comprehensive analysis of field texts is possible by first categorizing the data based on similarities and then contextualizing the coded categories in relation to each other.

Interview analysis

In the first reading of the transcripts, I wrote tentative codes (choosing science...choosing teaching, learning outcomes, teaching methods, good science teacher, science is ...) in

the margins for different segments of data. As I had stuck closely to the prepared interview questions during the interviews, the emergent codes were very similar to the topics of the questions being asked. On a second reading, I highlighted words in the different data segments that contained the information relevant to the constructed code. On the third reading, I used different colored post-it notes for each of the four categories in the interview. I went through each interview transcript and rewrote each margin code on one of the four different colored post-its. I then arranged post-its of the same color together. Within each color I grouped post-its that addressed the same category in columns on a sheet of paper. Each of these post-its recorded, along with the category code, the interview transcript name and page they corresponded to. Once the coding was done on paper, I proceeded to construct the categories on disk according to the inductive arrangement. I wrote rules of inclusion for each conceptual category which enabled me to test each interview quote's presence in the particular category. These rules were then expanded on to construct summaries and analyses for each of the sections.

Collage analysis

Once I had completed an initial analysis of the interview data, I examined the collages more closely. Initially I had not been sure I was going to use the collages as part of my final analysis. However as I viewed the video presentation the teachers had done, I realized that their metaphoric descriptions were helping me get a better sense of each of their educational beliefs and views. I realized then that this would enable me to triangulate the arguments I was building through the analysis of the interviews. Once I had transcribed the video presentation, I proceeded to build categories as I had done with the interviews. Each of the teachers had begun by describing their beliefs on the role of the teacher. They proceeded to share their beliefs on how science instruction should be carried out, what science as a subject meant to them, their objectives for their students and their views on collegial interaction. The five categories that emerged were 1) characteristics of a science teacher, 2) teaching and learning, 3) learning outcomes, 4) science is ..., and 5) collegial interaction. These titles were constructed so that they were similar to the ones for the interview data. I then separated each voice into these five

categories and constructed summaries and analyses for each. Once these were done I merged these categories (quotes, summaries and analyses) with those in the interview analysis.

Reflective work (memos and research journal) analyses

Some of my research journal entries have been included in chapter 4. The sections I have used are those that provide insight on my relationship with the teachers and my thoughts on the research process. I revisited the teachers' reflective memos once I had categorized the interviews and collages. I found as I went through the memos that two categories of reflective feedback emerged: 1) teaching science and 2) learning science. Teachers' comments were separated into each of these categories. Connections between the teachers' views on the TISD process, my observations of the lessons and the literature on reflective practice constituted the description of the reflective categories. This reflective feedback helped determine some of the suggestions for future research and the implications section in chapter 6.

In summary, data were collected in a number of ways to allow for triangulation that would strengthen the results. These methods were: interviews, collages, lesson plans, reflective memos and the researcher's journal. Each of these field texts was gathered over the course of implementation of the Teacher Instructional Strategies Development (TISD) group which ran between the months of August-October 2003. The different texts allowed for the presentation of views of the teacher participants and the researcher, through which a level of trustworthiness was established. Thus, teacher participation was possible in the collection of texts while in the field. However, constraints of time and distance inhibited similar participation in the analyses of these texts which took place in Canada. The next chapter involves a presentation of the results and analysis of these field texts.

CHAPTER 4: RESULTS AND ANALYSIS

Journal Entry (Hyderabad, India; Saturday, August 23, 2003):
Arrived in Hyderabad 11:20 pm Wednesday. This time feels different. There's definitely the sense that I'm here for a different purpose, "Strictly for work, not for pleasure" (like the notice on the computers at McLennan)...Also, things at Dilruba are so different without Nani, without Pyari. I miss their care, Nani's worrying, Pyari's chattering ...Went with Nana to PEGHS for the Investiture Ceremony (of prefects for the new academic year)...Found the occasion personally symbolic...as marking the beginning of my research responsibilities.

In this chapter the results of the project will be presented. This study was designed to answer the primary question:

> What conditions affect the implementation of constructivist instructional strategies (IS) by women science teachers at a girls' school in India?

The primary question was operationalized by defining two secondary questions:

1) To what extent is the implementation of constructivist instructional strategies at a girls' school in India affected by:
    a) teacher educational background and experience
    b) teachers' views on science and science education (teaching and learning)
    c) school environment, including opportunity for collegial interaction
2) To what extent does the use of constructivist strategies affect women science teachers' views towards science education (teaching and learning)?

Each of the secondary questions will be analyzed, based on the data described in chapter 3. The first section consists of character profiles of the teachers and the following four sections address the secondary questions.

Teacher Profiles

The interviews and cooperative lesson planning sessions gave me the opportunity to work with the teachers one on one. It enabled me to get to know the teachers better than would have been possible had we stuck to the initial plan of whole group planning sessions. The following character profiles were constructed from information gathered in the first section of the interview which focused on demographics, from my research journal and from conversations with the teachers. As the remaining portion of this chapter called for dissecting the interviews in order to make comparisons and see patterns, this initial section attempts to establish a more complete picture of each of the teachers. The teachers have been assigned pseudonyms for the purpose of this report.

❖ Shanthi

Shanthi was one of the teachers I had met in a small group discussion with teachers at PEGHS in August 2002. The teachers had been curious about my Canadian teaching experience and shared that they were eager to learn alternative teaching strategies for mathematics and science. I was glad to see that Shanthi was one of the teachers Mrs. Nazeer had suggested for the research project.

Shanthi had completed her B.Sc. with a major in Mathematics from Koti Women's College. She had done her B. Ed. at Andhra Mahila Sabha. Shanthi had taught for two and a half years, including four months at PEGHS, before taking maternity leave. She returned in June 2003 to continue teaching at PEGHS. Shanthi was teaching Chemistry to classes 7 to 10 at the time of the Teacher Instructional Strategies Development (TISD) project. She had previously taught Physics to classes 7 to 10. Shanthi was the mother of a baby girl. She juggled teaching full-time, spending time with her daughter and taking care of household affairs. Shanthi appeared to be struggling with the need to work and the guilt she felt for leaving her young child with her mother-in-law for the day.

> *Shanthi expressed a keen desire to learn and try new things. I'm really looking forward to working with her. I appreciate her honesty/modesty about her insecurities with teaching*

methods and her courage to overcome this by trying out new strategies. (Journal entry, August 27, 2003)

While things began as scheduled with Shanthi, we eventually found we would not have the time to complete three sessions of planning, implementation and reflection. Being a senior subject teacher, she was often busy providing students of class 10 with help in extra tutorials, leaving less time for conducting the research work. However, the two full sessions that we had (planning, implementation and reflection) were sufficient to get an initial taste and some practice with the constructivist approach. Shanthi's excitement at experiencing students' ability to balance equations with little previous instruction provides evidence of her desire to experiment with new strategies to further student understanding.

- **Sana**

Sana was in her second year of teaching and had the least teaching experience of all her colleagues in the research group. Sana had completed her B.Sc. (Biological Sciences) from Princess Shahdaan Women's College and her B. Ed. from Sharada College of Education. She was the mother of a toddler, a young boy, who was taken care of by her mother-in-law so that she could work full-time. Sana appeared to be well-organized and used her work time efficiently. Whenever I visited the staffroom I found her either marking, planning or taking care of some administrative work (sports day preparation, report card writing, drawing bulletin board posters).

Yesterday I got a sense that Sana might not have wanted to participate in the group. But today she expressed a desire to get right into the sessions...so we are ...tomorrow we do the interview, the day after we do planning session number one, and the first lesson will be implemented next week. Yay! Here we go! (Journal entry, August 27, 2003)

Contrary to my initial misgivings, Sana jumped into the research work whole-heartedly and was the first group member with whom I was able to complete planning and implementation of lessons. Sana easily volunteered a number of activity ideas for a given topic and already appeared to be using a hands-on/minds-on approach wherever possible. She had conducted a soil profiling activity with her students the previous year and had shown them various mixture separation techniques. On one occasion, I walked into the staffroom and found Sana showing her colleagues a large-scale model of a set of teeth that had been ordered in for a lesson on tooth

care. She was also adept at making connections between scientific concepts and students' lives and recording students' responses on the blackboard. Sana's lessons were very interactive, involving questions from and discussion with her students.

❖ Meena

The first time I saw Meena was on August 23, 2003 at the Investiture Ceremony which she was helping to coordinate. She seemed to easily move between various participants, organizers and audience members, ensuring that the event progressed smoothly, and stood out as a natural leader. This ability was reaffirmed when I found out during the interview that she had run her own elementary school (kindergarten to class 5) very successfully for two years before it had to be shut down because the premises were going to be pulled down and reconstructed. She hoped to reopen the school once she had got married and settled down.

> *She seems really sharp and eager to participate. Initially I felt a hesitance to participate (at the presentation on August 26, 2003). But she was quite warm and enthusiastic at today's meeting. I'm curious about her educational background as she seems quite articulate and confident. I found she was completing my sentences (regarding the research project objectives) more articulately than I was! (Journal entry, August 28, 2003)*

Meena had completed her B.Sc. (Biological Sciences) from Vanita College and her B. Ed. from Sharada College of Education, after which she had immediately started teaching. She had taught at PEGHS for four months prior to opening her own school. Once her school closed, she returned to PEGHS and had been teaching there for two years.

❖ Seema

Like Meena, I first met Seema at the Investiture Ceremony. We had shared a few words during the staff gathering at the end of the ceremony. Seema's warm smile and friendly nature made me feel comfortable on this day, my first encounter with the whole school staff.

> *I think I'm really going to enjoy working with Seema. She always seems to have a smile on her face. I felt her warmth and welcoming nature right from our brief encounter at the Investiture ceremony. I'm so happy she is participating in the project ...She wants ideas to teach Physics. She seems the most confident and trusting about participating in the research group. (Journal entry, August 28, 2003)*

Seema had completed her B. Sc. (Biological Sciences) from Princess Shahdaan Degree College. After this she did her B. Ed. from Sharada College of Education. Following this she pursued a post-graduate degree, an M.A. in Public Personal Management, although she had never worked in this field. Instead, she began teaching in a school and decided to pursue a teaching career. This was her fourth year at PEGHS teaching Bio-sciences and Physics to class 6. Prior to teaching at PEGHS, she had worked for three years at a co-educational school teaching Bio-sciences and Physics to classes 8 and 9. Seema was single and lived with her father and sister. Over the course of my time working with Seema, I learned that her father was ill and she was the primary care-giver. She also shared her desire and felt responsibility to see that a suitable match was found for her younger sister.

In summary, all four participants were young and well-qualified to teach science. They had experience varying from between one year and seven years. They had family responsibilities that meant they had little time outside of their work hours to spend on school-related responsibilities. They spent their work hours planning, organizing and implementing curricular, extra-curricular and administrative activities.

Results and Analysis

The second part of this chapter provides the results of the study. Each section consists of the conceptual categories that emerged from the qualitative analysis, as described in chapter 3, of the interviews, journal entries, reflective memos and collages that were gathered over the course of the study. A discussion of the results will be provided in chapter 5.

1a) Teacher background and experience

The first section of the first secondary question dealt with the teachers' educational background. To understand the influence of teachers' background on the use of new instructional methods in the classroom, I asked the participants to share what factors had influenced their pursuit of a science education and teaching as a career. Three conceptual categories emerged that described

various people and experiences that directed them into their current careers as science teachers. These categories were: 1) Choosing science and teaching, 2) Memories of teacher role models, and 3) Preparation for and the first years of teaching.

Choosing science...choosing teaching

This category describes the experiences that led the participants to choose a science stream at the secondary level (classes 11 and 12). They also identified events that led them into the field of education. Two of the four participants, Sana and Shanthi, described their interest in science in school.

> *...Because Science is a wonderful subject, no? So many interesting facts about that so I choose Science. (Sana, interview)*

> *Right from my school days, from schooling I was interested in, um I can say my favorite subject was Mathematics, Physics and Chemistry(MPC), that's how I have taken up even in Intermediate program MPC and then I continued with it. (Shanthi, interview)*

For Seema, it was a career choice that made her choose science and later teaching.

> *Actually when I was a student I had the intention of becoming a doctor...And later on when I could not proceed with my medical degree I have joined science stream B.Sc., then because there are no further, what to say, scopes there I could not do my post-graduation level there, instead I joined education, that is B. Ed. And from there onwards, even when I was not trained, I was doing my teaching practice, I was continuing with it. (Seema, interview)*

While she was teaching in a co-educational high school, Seema realized she found teaching interesting, so while continuing to teach she began and completed the B.Ed program. Meena found that she enjoyed learning about teaching methods and that she had a natural aptitude for teaching.

> *...When I was in Degree my cousin was doing B. Ed. so I helped her a lot while she was doing, so that was also a type of, that thing, brought an encouragement in me, the ways and the methods of teaching, as I loved teaching I was more interested to help her, so that led me into B. Ed. (Meena, interview)*

Both Sana, who tutored at home, and Seema, who was teaching before doing her B. Ed., shared that these early teaching experiences made them realize that they enjoyed teaching and it was something they would like to pursue as a career.

Though gender was not included as an influencing factor in the research questions, it emerged as a factor specifically referred to by the teachers themselves. As Sana and Shanthi explained, other factors influencing their choice of career were their parents' encouragement and their own notions about the suitability of teaching to their roles as wives and mothers.

> *Nobody encouraged me to take Science in particular but for teaching both my parents, they encouraged me....Teaching is...I love teaching, yes. Before also I used to take tuitions at home. So I had a lot of interest in teaching. Because as a woman no other profession is as good as teaching, so I opted teaching only. Isn't it? In offices and all that it is not that much good for a woman to do work in there. (Sana, interview)*

Along with providing a suitable work atmosphere, the participants perceived that teaching was conducive to the role and lifestyle of mothers and wives.

> *We were absolutely given the freedom to take any subject, whichever field you wanted to take. But definitely in my B. Ed. program, I mean to take up that, definitely my parents and my grandfather inspired me to take that career, to take it up....Because what they perceived the idea behind it is like if you're married that is a thing in India where that is given a priority, even your child and you can go together, so that um be in one school...The other fields there are, there are openings but to my caliber and to my interests I think this is the best profession I feel is more convenient. (Shanthi, interview)*

Thus, the participants identified the following conditions as influencing their choice to study science and education: an interest in science and careers in science, teaching experiences such as tutoring and helping older cousins with B. Ed. projects, parent encouragement to pursue a teaching career and the belief that teaching was a suitable career for a woman.

Teacher role model memory

Three of the participants, Meena, Shanthi and Sana, described a teacher from their school days that had been a role model to them. The participants indicated that they hoped to cultivate the behaviors and characteristics of these teachers. Meena shared that her science teacher had been

particularly inspiring and recalled a lesson on digestion that had been very clearly explained by this teacher.

> *Like first I'll talk about teaching. Like teaching, it was like an urge, I can say it was like an in-born quality in me. Like, I used to imitate my teachers and of course my science teacher I was very much inspired by. ... The way she used to teach. The very next moment when I enter my house I used to wear a sari and act like her. (Meena, interview)*

Shanthi and Sana also gave examples of biology, mathematics and physics teachers who had been instrumental in them developing an interest in teaching.

> *My mathematics teacher had a great influence on me. She was the one that inspired and first of all made the subject interesting for me. ...Even our physics teacher was good. (Shanthi, interview)*
>
> *...Our biology teacher was wonderful. He used to explain each and everything so nicely that we had so much of interest to opt for that only, so I opted that. ...Every concept he used to explain well with all the real experiences, with dissections, models, charts, everything. ...He was very friendly to us, he never used to scold ...Everything, whatever he said we grasped that, so without anything punishments.we can write nicely, he used to appreciate every student, so like that we also want to be, like that so that our students will enjoy with us while learning also. (Sana, interview)*

Sana also described how her teacher's caring and supportive nature had encouraged her to do well in biology. She hoped to do the same for her students.

Thus, three participants identified the following qualities of their teacher role models that made them memorable: ability to make science interesting, how they dressed, friendly, caring, supportive, approachable and ability to explain concepts clearly. There are similarities between these qualities and those the participants' identified as representative of "a good science teacher is...", as seen in the conceptual category with the same title on page 58, of this chapter.

Teacher education and first years of teaching

I asked the teachers if they felt that their respective B. Ed. programs had prepared them for teaching. This question helped to understand how their B. Ed. training had influenced their teaching ideology and investigated whether it was one of the conditions that determined their

receptiveness to pedagogical change. The teachers shared many aspects of the program they felt had been useful for their beginning years of teaching. They also shared aspects of the program that had not been beneficial.

Meena described the "situational learning method" that she had learned during her B. Ed. program, which she now used in her science lessons.

> *...This is the method that we were supposed to follow, creating the situation for them, then the answers will be coming out from them, there's no need for us to explain. And this activity is people-centered, like when we go on speaking and speaking, they won't listen to you and 45 minutes you have to spend in the class, isn't it? So we must keep them involved in the lesson. (Meena, interview)*

Sana said that she found learning about the psychology of a child particularly useful. She also commented on how hard she had worked in the program and that this was a quality that was necessary, particularly for the first few years of teaching.

> *...Because we as a graduate we know about all the studies. But we don't know how to teach that, how to express our views about the content about the curriculum. So the training which we had, it prepared us, how to know about the psychology of the particular age group, how to teach them, how we can come to their level, to explain each and every concept. . .They maybe of class 3 , class 4 so small they are, but we have to come down to their level. It helped a lot. It is because of that only we can able to teach perfectly .... (Sana, interview)*

Seema spoke of the value of the practical aspects of the B. Ed. program such as micro-teaching lessons that she had practiced in front of her peers and the effective use of the blackboard for scientific diagrams and explanations. She also identified aspects of the program that she did not find relevant to her teaching practice.

> *It has prepared but whatever we are taught theoretically it doesn't go into teaching. Whenever we are given practicals, that applies to us but theory part it just fades off, but only the practical part whatever we have been doing as teacher-students that applies into our (sounds like) transfers ...(Seema, interview)*

Seema had not found book knowledge a useful part of her preparation for teaching. Shanthi, on the other hand, had hoped for additional books that would provide her with advanced scientific information.

> *...I'm not thoroughly prepared how to face up to the challenge, but in each area we were exposed to many areas .... I was in search of the books which give more information, definitely because when above average students would ask me a question that I was not able to give the right on the spot answer to it. And I was thinking the reference books could have been given to us much in advance or before we were taken to the teaching practice. (Shanthi, interview)*

The teachers for the most part found that their B. Ed. programs had sufficiently prepared them to deal with their first year of teaching. Training in child psychology, instructional methods, classroom management, availability of resources for reference and opportunities to practice teaching were some of the areas that played a role in how well they felt prepared to face their first year of teaching. Over their first years of teaching the participants felt that their competence in the classroom increased and that their job got easier.

> *It has improved, it has improved .... No in previously whatever I used to do, I used to feel a little, that is not confident in myself. Now whatever I do I am confident enough and I know what my girls are going to learn from it. So that way I have improved my teaching process. (Seema, interview)*

> *Yah, in first year it was very difficult for me because I don't know about the psychology of the children, how they can react to that particular lesson, I don't know any children at all. I don't know what they know. I just know that this is the lesson I have to teach this.... So now in the second year I come to know about what they know, because last year also I taught the same students now it is becoming very easier and easier for me ... (Sana, interview)*

The participants' ability to reflect on and alter their pedagogy to enhance student learning in their first years of teaching indicates their commitment and professional approach to their practice.

Thus, the participants' accounts of their teacher education program and their first years of teaching indicate the comprehensive pedagogical training and growth they were exposed to. Although they found some experiences more useful than others, overall they felt they were well

prepared to enter the teaching profession. Their first years in the classroom were a period of growth and change which led to an increased competence in teaching science.

1b) Teachers' views on science and science education (teaching and learning)

The second section of the first secondary question was designed to gain an understanding of the teachers' views on the nature of science and form of science education. The teachers talked about how they define science, learning outcomes, teaching methods, and the qualities of a good science teacher.

Their views with regards to science learning outcomes might be understood when compared with idealist, realist, pragmatic and existentialist philosophies. The teachers' view that science was based on and needed to be applied to real life experiences corresponds to a pragmatic philosophy. Pragmatism is based on practical experience and use of the scientific method, it also promotes critical thinking skills. The pragmatist would believe that reality changes and is based on interaction with the environment. An idealist would promote the study of the great books and rely on the wisdom of the forefathers; a realist would subscribe to rational thinking based on logic, reason and abstraction; and an existentialist would acknowledge subjective and pluralistic knowledge and reality based on individual experiences (Ornstein & Hunkins, 1998). The epistemological ideologies against which the teachers' views of science were compared were positivism and constructivism. A positivist approach to science would perceive science as being objective and impersonal, unaffected by the scientist's personal views and beliefs. A constructivist approach to science adopts the perspective that science is subjective and is influenced by the scientist's personal views and beliefs. Science is viewed as tentative and subject to change with growth in technology and inclusion of multiple perspectives (Grennon-Brooks & Brooks, 1993).

Examining the teachers' views initially with regards to the educational philosophies (idealism, realism, pragmatism and existentialism) made it easier to identify where their views lay along the continuum between a positivist and a constructivist approach to science education.

Science is...

The teachers' comments in this category represent their views on the nature of science. When asked to describe what came to mind when they thought about the subject science, the teachers provided very similar answers.

> *Science, I feel, that is, it's first hand knowledge, first of all. Then, you can do it, that is I have interest in doing what is, that is you can learn by doing something, that I have it, and so I joined the sciences. ...That is, we do it and we learn. ...Knowledge of facts, principles, that is, the underlying principles of experiments, what all theories have been put forward, those principles and all. (Seema, interview)*

Meena provided similar characteristics to describe scientific knowledge and processes.

> *Science is a very vast subject to speak on and it's a never ending process I think. And it is mainly "Learning by doing" I define it as, when you do something you learn, through activities or maybe any experiments and all. ...Like, you can relate what all is going (on) around you with science, isn't it? It's the knowledge of fact; science is the knowledge of facts that is happening around you. That is, you need to know, you need to have a curiosity to know more about that . . . (Meena, interview)*

Shanthi and Sana shared that science consisted of information applicable to our daily life experiences. While Shanthi spoke of the inquiry-oriented aspect of science that grew from an interest in the environment, Sana shared that this aspect was what made science "more interesting".

> *It is mostly related to the day-to-day life, surrounding, one should have the (sounds like) "interest" to know what actually we are having ...That's how science is an inquiring, like, that's the idea I have about it. (Shanthi, interview)*

> *The real life experiences we have in teaching science, so that is applicable in our life also, that's why it's more interesting. (Sana, interview)*

The teachers' beliefs are supported by the images they used in their collages (see Appendix H for the teachers' collages).

> *(cactus plant in desert) Science is a wonderful subject, it is not like something extinct as well as somewhat non-living. (a field mowed into a maze) We can create amazing things*

out of it, (rows of colorful tulips) as well as we can create something wonderful. (Sana, collage)

And how I see science is, (dead tree trunk) I've taken up science because it is nothing dead or fossilized like this but it is (colorful wild flowers) something that is living ... (Seema, collage)

Science is represented as growing and changing, as something that is alive. They also depict science as useful for the creation of structures of aesthetic value.

In summary, some of the things that the participants identified as characteristic of the field of science were: first-hand knowledge, knowledge of facts, related to daily life, alive and changing, a creative process, involves inquiry. Their views paint science as an interesting and relevant field of study with regards to their students' personal survival and career endeavors.

Learning outcomes

The teachers were asked what three things they would like their students to know when they left their science classrooms at the end of the school year. They identified a variety of skills and attitudes they hoped to cultivate in their students.

They must be able to relate with their day to day life is one thing....They must be able to relate their classroom activities ... connections with what they experience...And interest in science of course...There are so many skills that you can develop here. When you talk about my subject I say, that drawing is one of the skills that they can learn. And aesthetic values, even values if you count, appreciating the nature, like that...(Meena, interview)

Sana also shared the pragmatic perspective of science education as useful for daily life. Sana also identified outcomes encompassed in the scientific method.

So whatever we are teaching them they should apply in their life, isn't it? It must be applied, useful. They should develop the creative thinking in themselves...Observation; they must observe everything carefully and must be very innovative so that they can prepare something on their own. (Sana, interview)

Seema provided an example of how she taught her students to make scientific observations.

...Now their observations can be seen by them not only in science, just because I go on telling them, "see when you go when you walk around". When I teach them about plants I told them when you go around, we have one topic called Classification and naming of Species, therein we give them the common name and the scientific name. Whereas in the syllabus, the curriculum that is designed it has only 8 to 9 names, but what we have done is we have labelled all the trees according to their scientific names ... Whenever I get into the class the first five minutes I have to spend on hearing to them what they have seen on the school grounds ... (Seema, interview)

Shanthi spoke of the need for students to remember what they learned so that they perform well on school and government examinations. Students face high pressure to do well as they compete with their peers to obtain the few seats available at colleges of higher education.

Basically it's all a marks-oriented program only, so I want them, whatever they learn, to retain it for a longer time and see that it is made use in whichever category it is asked for...Only thing is that it should retain for a long time. (Shanthi, interview)

Similar outcomes as those in the interviews emerged in the analysis of the collages. The teachers exceeded my imposed limit of three learning outcomes and found images to represent appropriate scientific qualities such as *curious, observant, understand scientific concepts clearly, perseverant, ambitious, apply their knowledge* and *team work.*

(magnifying glass) And then when we teach them with a clear concept, with a clear idea, a magnifying glass which is used here (children looking at turtles) and allow them to learn and observe things ...(person holding a human skull) and all these when we put in them, they develop a character or they have the inquisitiveness that develops in them, or they try to do things on their own, (children at the arcade-like computer box) they participate, they apply it and (boy with parachute)individually they try to do I t...(goes back over the different pictures) so all these character(istics) if we,. that is, they are observant, they are making things clear, inquisitive and (marine biologist at work) probing into the idea ... (Shanthi & Meena, collage)

The three collages contained images of the teachers' views that students needed to have a clear understanding of what they were learning. Shanthi and Meena's image of a magnifying glass indicated their belief that they could make concepts clear through good instruction. Seema's and Sana's images portrayed the act of understanding as being a freeing experience.

For my students I would like (three children with adult) to develop a curiosity in my students so that they would (three children looking at a book) explore things. And develop (person working with bones) learning by doing (photographer squinting over flowerbed), critical thinking in them and (people at a photography exhibit) observation so that they would have a clear picture of what they are learning and (bird caught in fishing net) not entangle themselves in doubts. (Seema, collage)

Sana's description also showed her high expectations of her students. She wanted her students to aspire to set and attain academic goals. She wanted them to persevere towards these goals in the face of possible challenges along the way.

...(group of women and children peering at something) by developing curiosity among the students (archer aiming at something) we must have some target in what we are doing (little girl watching with folded arms) so that the students can understand, they can extend to their heights, they must not be binded in some chains or knots, they must be free so that they can fly like butterflies (butterfly on a leaf/pasted as if in flight) and can grasp the knowledge (watch dial). They must be time consciousness, (archeological diggers) they must work with curiosity and have the observation capacity also. (canoe team) Teamwork should be there among the students ...With any work we should not show them back (person's back seen as s/he walks into the horizon). And we must also make our students not to show their backs. (Sana, collage)

Seema's images of learning as a continuous process consisting of exploration and discovery also matches constructivist ideals for science education: science as tentative and changing, as being an on-going process of paradigm construction and alteration.

...(mountaineer on snow-capped mountain) which you can explore and find out new things, as learning is a continuous process...(penguin flapping its wings). Learning should be an enjoyable process. (Seema, collage)

The teachers' comments reflect their views about the outcomes of a science education for their students: to be observant, to gain a clear understanding of the world in which they live, to be able to apply what they are learning to their daily lives, to appreciate nature, to have a sense of curiosity, to be creative, to persevere, to not feel burdened by their academic responsibilities. In order to see how the teachers aimed to achieve these outcomes, I asked them to describe their teaching methods.

Teaching methods

The teachers described the various science teaching methods they had used. I was interested in how they taught science and curious to see whether or not the methods they used were different from a constructivist approach. Meena gave an example of the situational learning method.

> *...Like, I create a situation, I go from the basic what they are known to, from known to unknown then I take out the topic from them. Like for example, if I have to teach agricultural practices, so I'll go about, like, "What are the basic needs of our life?", "What are the requirements of life?", then they of course say, "Plants, food, water, air", and all. Then I ask them as to, "Where do you get food from?" so they say, "Plants", "Where are plants grown?", "In the fields", "Who grow them?", "The farmers", then "What do you call the process of cultivating crops?", then they of course say "Agriculture"; like that I go about taking a topic.... So this is called as a "situational", creating a situation for them. Like, to make more interesting we can even ask them as to, "What you do when you want to plant in your house?" then they'll come out with the steps, then you can relate those steps with the farmers that do in the fields. (Meena, interview)*

Seema described projects on water and the solar system that she had had her students work on by using reference books in the library.

> *... Project work and I also do "Learning by doing" methods. That is, now to find out the width of a coin, that is the side walls of it, now if individually each coin is taken, you don't get the accurate measurements of it, but if you keep them in a heap of 10 or 20 you get some measurement you can divide it and you can get the accurate values of it. So I do it personally in the class and even I ask them, now if I have done it with a certain denomination in the class, I ask them to do it with another denomination at home and come, so that they also do it by themselves and learn. (Seema, interview)*

Seema also explained that in certain topics, such as "Science and its importance", the lecture method was the most appropriate method she could think to use. She did not feel that this topic lent itself to hands-on activities as easily as other topics in science.

In India, senior class (classes 9 and 10) teachers find it difficult to conduct activities in the classroom because of the need to complete the prescribed curriculum early to be able to spend time reviewing for the board exam. Shanthi taught these classes. She said that she mostly

lectured, but also conducted laboratory experiments depending on the availability of equipment and materials.

> *It depends on the topic. But mostly it is lecture method ... I explain to them, the only aid being the blackboard, and then I dictate the notes to the children, sort of the running notes. Then the chemical properties which they are having in the labs, that will be brought to the class in a demonstrations .... (Shanthi, interview)*

Shanthi gave an example of a project she had assigned her students in the past. It had been both practical and picture based and was used to explore the concept of pressure. The students were required to compare and contrast the pressure exerted by flat-heel and pointed-heel shoes, larger animals to smaller animals, and loads carried by single-wheel and double-wheel trucks.

Sana gave an example of how a lesson on balanced diet had altered her students' eating habits.

> *See for these food habits, I do balanced diet. So most of the children they have the habit of only eating chapattis. They don't like eating rice or eggs, someone don't want to drink milk, like that. So there is a deficiency of that particular nutrient in the children. So when I taught that all the nutrients are necessary for us, for the body growth, for all the body parts, no? . . . I asked the girls, you are not eating this thing, so you must bring it in the lunch. So they are bringing and eating. Other girls are coordinating them "Didi, she is eating, she is bringing" .... (Sana, interview)*

Sana also provided examples of demonstrations, such as soil profiling and water purification, that she had done in her class. The participants provided other examples of how they made connections between science in textbooks and everyday experiences. Sana spoke of a lesson on First Aid and tooth care, Meena on nutrition, Shanthi on pressure and surface areas. Seema described how a discussion on Mars progressed into a lesson on gravitational force that keeps planets in motion at certain positions in the solar system.

For example, in September 2003 Mars' distance from Earth, at 56 million kilometers, was the shortest it had been in 60 000 years. Mars could be clearly seen with the naked eye on a clear night. Posters, including news reports, were displayed on the school bulletin boards during this time.

...We are able to relate it to the current facts, as how presently we have. Now today is my class of physics, most of the time we have finished, I have taken up my time for discussing Mars ...Because the girls are curious in knowing about Mars and we started discussing the whole solar system ...Yes, definitely because we ought to give them current knowledge. ...that is, they have a confined syllabus but when I talk to them about measuring different things and how accurately according to the standards of measurement and all, what should be there at the, just underneath the weight that is present there should be a lead seal there and if it is not there the person is cheating us. Definitely they say that "Today itself we're going to go to the shop and we're going to find out whether that person really cheats". (Seema, interview)

The teaching and learning images used by Shanthi and Meena possess constructivist qualities. The images of learning take place in situations outside the classroom, freeing students from the burden of perceived complexity, valuing individual work and recognizing the need to prepare students for global participation characterize constructivist beliefs.

(man carrying wooden log) Then they don't feel burdensome. (caged bear)And this kind of teaching should be done not only in a closed room or in the confined four walls of a room but should be, (boy with parachute) we should allow them to do on their own ... And giving the individual attention and all these, (person sowing seeds) when we sow all these factors into them (picture of the globe) we are preparing them for the global standard. (Shanthi & Meena, collage)

Constructivist teaching calls upon teachers to assess for understanding prior to introducing new concepts or extending conceptual understanding. Seema and Shanthi's comments on the difficulty in moving ahead unless students understood a topic is indicative of this characteristic of constructivist instruction.

...So only when they understand I proceed with my next project, that is, the following lesson. Otherwise I get held up there and I explain to them till they understand. (Seema, interview)

...How far they have learned or whatever experience which I have gathered and then given to them ... from teaching. And I'll be totally depressed if they don't come out with it, then I again work upon it and then carry on. (Shanthi, interview)

Lecturing was the most common method of instruction and students were asked to copy notes from the blackboard. The teachers effectively used the blackboard to record students' responses, draw diagrams and provide notes. Other methods such as demonstrations, laboratory work,

projects and situational learning depended on the availability of resources, equipment and time. The teachers were adept at making connections with the daily lives of their students through the use of questions and examples. They spoke of being able to read their students' faces. The teachers said that students' active participation, their questions and the quality of their assignments were some indicators of their engagement with the topic of study. Testing was the common form of assessment and was as much a tool to judge the students' learning as to judge their own instruction. When students did not perform well on tests, the teachers recognized the need to re-teach the problematic concepts. When students did well on tests and exams, the teachers felt this was a reflection of their hard work and felt rewarded.

A good science teacher is...

The teachers were asked what would qualify as characteristics of a good science teacher. The purpose was to see if any of these characteristics matched those of a constructivist educator. Some characteristics as identified by Grennon-Brooks and Brooks (1993) are: promotes student autonomy, uses raw data and primary sources, promotes higher order thinking, allows students' responses to drive lessons, inquires about student understanding of concepts before sharing their own understanding, asks thoughtful, open-ended questions, allows wait time before posing questions, uses discrepant events to encourage discussion, nurtures students' natural curiosity.

Meena used a proverb to describe what she considered a good science teacher.

> *Qualities to develop interest in science, like a proverb goes like, "A poor teacher tells, isn't it, an average teacher explains, a good teacher demonstrates and a great teacher inspires". So, a science teacher should be inspiring, she should create a curiosity in children, that is one of the most important qualities I think of a science teacher, that is the one. (Meena, interview)*

Shanthi focused on the skills a good science teacher would inculcate.

> *She should be too resourceful, then only she can prepare them in the class for the outside world. Yes, definitely, like one, I should be thorough enough to have that and present it to the class. It's only the exposure, which I need. (Shanthi, interview)*

Sana and Seema provided similar characteristics and described the nature of the relationship between such a teacher and her/his students. They noted the impact that a good science teacher could have on his/her students' learning.

> *Creative, innovative, discoverer and we should have patience also, main thing is patience, we have to deal with so many students in a single day, we must have patience. Sympathetic also towards the students, because always being fear and all that students can't learn properly. You should be like a friend to her, then they can learn very easily... (Sana, interview)*

> *Well, a science teacher has to be an innovative person herself, a curious person to know everything around her; then, preparing before hand is more important, then answering the queries to your children, otherwise they go off with the same questions they go and again they have those same questions, they won't be able to solve those questions if we don't help them out. So we need to have a correct and a thorough picture of what our students are studying .... Innovative, curious, having a thorough knowledge of what you teach, how you teach and what you teach, both. (Seema, interview)*

The teachers used images depicting general characteristics of a good teacher, such as caring, friendly and hardworking. They also provided characteristics specific to a science teacher, such as curious and exploring. They each provided metaphors for these teaching qualities through their choice of images.

Shanthi and Meena portrayed a teacher as a nurturer and friend.

> *(Singapore Airlines woman and children) This as a teacher it shows that, it reflects the character of a teacher - caring, very friendly with children. (Shanthi & Meena, collage)*

Seema saw herself as a pathfinder and a guide, accompanying her students on their academic journeys. Her metaphor of the teacher as a pathfinder implies that teachers are learners seeking out knowledge and better methods in order to teach. The metaphor of a guide implies her role as a fellow traveler with knowledge to share about the academic encounters along the way.

> *(group of older women) As we are social beings, (monk and smiling boy)I am a friendly person. (guide holding the light) So for my students I want myself to be a guide for them*

always and (hands with chicks) extend a caring hand to them. (person on suspension bridge) And I also see myself as a pathfinder. (Seema, collage)

Sana used the image of a mountaineer persevering to attain his/her goals. This metaphor reflects her ambition to set goals and persevere towards them no matter what challenges come her way. She shared similar high standards for her students when she said that teachers needed to possess the ability to "sharpen our students".

(man gesturing enthusiastically) So that we can explain it to our students in a better way and be perfect in whatever you are explaining ...To explain myself as a teacher we must try that we should (waves and truck on sand dunes) not be left behind by just seeing the nature, we should have the ability as well as (mountain climber looking over the horizon) curiosity to reach the heights. To (diver taking pictures underwater and mountain climber against the sunset) do the hard work whether it maybe down under water or it may be the mountains. (child grasping adult hand) With love and caring we must treat our students. (sharpened pencil) We must have the ability to sharpen our students. (animal skeleton in red sand) We must not think something is extinct, we must explore it. (Sana, collage)

In summary, the participants provided a number of characteristics to describe a good science teacher. Some of these included a person who was curious, inspiring, knowledgeable, resourceful, well-prepared, creative, innovative, inquisitive, patient, caring, friendly, approachable and hard-working.

1c) The school environment, including opportunity for collegial interaction

There was an atmosphere of care and support, energy and diligence that I gathered from my experience at PEGHS. The different members of the school community, students, teachers, administrators, secretaries, librarians and caretakers all took great pride in the school's achievements. I had been curious about how the participants felt about their school. The physical, social and professional atmosphere in a school plays a role in enhancing or inhibiting pedagogical growth. In answer to the third section of the first secondary question, I sought to understand the possible links between the conditions at the school and teacher development. These are categorized as the teaching environment, professional development opportunities, and collegial conversations.

Teaching environment at Princess Esin Girls' High School (PEGHS)

The statements in this category represent teachers' reflections on conditions that made their teaching experience at PEGHS unique. They spoke of how the conditions at the school affected student behavior, which in turn influenced their practice.

> *...We are having something different atmosphere in this school ... All the students and teachers relationships is like friends, we don't have any difference between each and every student. So first of all it, the building mainly have one of the factors. ... Nice spacious classrooms, everything we are having everything so students used to enjoy sitting in the class also, while strength is also less. (Sana, interview)*

The teachers shared close relationships with their students. The participants spoke of their dual role as teachers and parents.

> *...I mean all of the parents are not educated, one of the factors is that and we have to work for them as parents as well as teachers because we can't expect the parents to help their children out so mostly we try to complete all the things at school itself, mainly because of their background. .:. (Meena, interview)*

Seema explained the need to play this dual role so that their students would have a fair chance at doing well on competitive examinations.

> *See not all are, what to say, above average, some are below average also ... so we have all categories of students ...but those below average ones also should be able to understand us, that way we take the, I take the lesson plan. ...I don't encourage them to take tuitions and most of our students don't ... (Seema, interview)*

Seema shared how her students felt comfortable asking her a number of questions in class. These classroom interactions were testimony to the rapport she shared with her students. The teachers' and students' schedules were set up by the school's Assistant Director to allow for this. Sana recognized the need to encourage her female students to do well. In recent years the teachers noticed that most of the students had plans to continue studying after they graduated, unlike previously when they either left school before graduating or got married right after.

Yes, I give more importance on girl education, for girl-child education because it is very necessary for a woman to be dependent on herself. So education is one of the main things. So I encourage the girls to study well. Yeah. ...and I talk with parents also. They must be very strict with their child, so that they are spending a lot of money, isn't it?. (Sana, interview)

The teachers worked towards creating a safe and supportive environment. In this, they were supported by the school administration, which worked hard at maintaining a limit of thirty students in the classrooms.

Thus, the participants identified a variety of conditions that made the school a unique place to work in. According to them, the well-maintained school grounds and facilities, the limited class sizes, the relationship between the staff and students, the commitment of the teaching staff and the recognition given to girl-child education were some conditions unique to PEGHS.

Professional development opportunities

The comments in this category describe opportunities available at the school for professional development. During my first week at PEGHS I attended a workshop, along with two other teachers, organized by the ICSE board (Indian Certificate School Examination). The ICSE board designs the national school curriculum which is followed at PEGHS. The workshop focused on applying Bloom's Taxonomy to questioning in the secondary science classroom. The workshop was being offered because recent revisions in the board examinations were geared towards applications-type questions. Such workshops were made available to the teachers at the school through the school Directors.

Meena spoke about the initiative of the school administration to promote staff development in the current academic year. However, at the time of the research study, they had not had the opportunity to use this time for what it was initially intended. Meena also described a science workshop she had attended the year before.

Yeah, working on 3rd Saturdays it started this year only. But still we didn't have any, like, collaborative work only, or sort of, like, there's one question on collegial work, isn't it? But here because of lack of time and more ... mathlab (meaning, *in Hindi) more responsibilities, we couldn't go for that, we won't go for the collaborative work. And*

with you we're doing it for the first time, I think that this will turn out to be beneficial for us .... Workshops. we do go for the workshops. Last time I attended the workshop on teaching aids.... Like, it is mainly based on Physics experiments. I thought I could have taken a Physics teacher along with me. The Optics and all the lenses, mainly the aids were based on that. And there were few, of course there were a few Biological models ... it was just showing, giving an idea how to make, improvise, using low-cost materials how to make models and all .... Only one workshop I attended last year. (Meena, interview)

The school Director Mrs. Nazeer's initiative to use one day every month for staff development reflects her desire to improve pedagogy and curriculum implementation. Her vision for the school encompassed nurturing a collaborative and professional atmosphere. The manner in which staff meetings were conducted, with maximum teacher participation in the planning of events as well as opportunities for feedback, was testimony of the healthy workspace she was working towards establishing. The library was a focal point in the school and was used extensively by both students and teachers. Besides books, encyclopedias, local and national newspapers and periodicals such as "Down to Earth", there were regular subscriptions to teacher magazines providing information on various topics such as teaching methods, conferences and student achievements. Given the many responsibilities, curricular, extra-curricular and administrative, the challenge of instituting on-going professional development is understandable. By offering internally and externally organized teacher professional development, the school was attempting to nurture an atmosphere of pedagogical growth. In such an environment a school-based professional development project such as TISD is more likely to be embraced.

Collegial conversations

The teachers' comments in this category reflect the nature of collegial conversations. The teachers at PEGHS had staffrooms on each floor where they were able to work on planning and marking. Approximately five or six teachers shared these workspaces where they also spent time socializing and sharing their teaching experiences. I spent time working with teachers in their respective staffrooms and got to know a number of the teachers I was not working with as well. A flask of tea was always present, or on its way there, and there was always enough for an extra mouth! I observed the teachers using these spaces to share teaching ideas, discuss school events; in general to support each other personally and professionally.

Sana shared how the teachers sometimes engaged in collegial discussions on effective strategies and activities to teach certain topics. She said that they discussed the appropriateness of those ideas for students' understanding. Sana gave the example of how she had used Seema's idea of using the students' lunches to teach nutrients in our food.

> *...For some topics, no, it will be difficult to say what activities should do. So we will discuss among ourselves, particularly this topic, how we should teach this, whether the children will be comfortable with this, we used to discuss. Because I and Seema we both used to sit in the same spot we discuss about.... Once I discussed with her, um, what topic was there? About this nutrients only, I asked her what activity to do, so she told ask them to bring daily one one thing in their lunch (both laugh) so I asked the students to bring that. (Sana, interview)*

Seema, who shared the same staffroom as Sana, also said she found it beneficial to speak with teachers who taught the same subject.

> *...See whenever we are free, or if we have some questions, or if any of the teachers has a science background, we talk to them and we say that "We are doing this..." and others if they have any questions, then first we test if ourselves, whether what we are saying is right, so then we go in (sounds like) the habit. So that way collegial interaction it is helpful. (Seema, interview)*

Meena shared a workspace with teachers from different subject areas. She felt that due to this and their different teaching times there was little opportunity for conversations centered around teaching particular subjects.

> *Usually everyone will not be there, will not be present at the same time, because of the classes and all. And that too, different subject areas will be sitting. More of the house stuff will be spoken instead of this. (Meena, interview)*

The teachers' collages portrayed their beliefs about collaborative work to generate new ideas.

> *(people working on an archeological dig) And this picture here, it reflects the teachers doing their own work and the teachers doing their own work, they come up with new ideas, they are exploring. (group of adults sharing a joke at work) And once they try it out they are sharing it, in this picture sharing their ideas. (Shanthi & Meena, collage)*

And about teachers, (lone bird in a bush) they should not be isolated, if they (large groups of penguins) have teamwork they could explore new things. That's all. (Seema, collage)

While teachers do individual work, it need not be done in isolation. A healthy and vibrant work place was seen as one where teachers worked in teams, trying out new ideas and sharing them with their colleagues.

By co-mentoring each other, the teachers and I were able to share our teaching experiences and develop lessons. In their reflective memos, the teachers shared their thoughts on our work together.

Working with you I found that team teaching or involvement of one or more person on a topic to teach is better than the individual teaching method. First of all, the teacher herself will try that her presentation will be the best and it could result in the benefit of the students. If we adopt the team teaching method like we are doing this lesson, sitting together and planning, sharing our thoughts and experiences ...make a lot of difference in presentation of the lesson to the students. (Sana, Reflective memo)

During the TISD project, collaborative work enabled us to maintain our focus on the students' cognitive abilities and interest in the topic being covered. Seema summed it up when she said:

Working with colleagues in teams is always beneficial as we share our teaching experiences and the teaching-learning process becomes more effective. (Seema, Reflective memo)

Thus, the teachers stated that they consulted their colleagues for ideas on how to teach certain topics. Although their shared work spaces were conducive to collegial conversations and a place to get their work done, it also made for a setting in which they could relax and enjoy personal and social time. The teachers found that working collaboratively on constructivist lessons resulted in better lessons as it was easier to focus on the students' abilities and interests. Team teaching also kept the teachers and me accountable to each other. I found we were able to generate a number of ideas for the topic being addressed in the lessons we planned together.

2) Teachers' views on science education, following implementation of TISD

Engaging in a reflective process is an important part of data collection and analysis while conducting action research. The teachers and I were able to give each other feedback on the planning and implementation of the lessons, by writing reflective memos over the course of the TISD project. The teachers' comments reflected the impact these lessons had on their views on science teaching and learning.

Teaching science using a constructivist approach

The teachers shared how using constructivist approaches expanded their views on pedagogical knowledge and skills. Shanthi spoke of how her knowledge of science and science teaching, by making connections between concepts, was enhanced in the lesson on balancing chemical equations.

> *I never thought that the class would go on so smoothly. After all, it was the idea of "Conservation of mass" which perfectly helped them to balance chemical equations. To be frank, even I felt that correlation between balancing and conservation of mass only, made me to teach the children in the correct way. Thanks for this! (Shanthi, Reflective memo)*

During the lesson on balancing chemical equations Shanthi shared the connection between conservation of mass, covered earlier in the school year, and the need to balance an equation. She also drew an analogy between algebraic equations and chemical equations. The students making the connections with algebra were able to balance equations with little teacher help.

Seema found that conducting small group activities enabled her to circulate around the classroom and provide individual attention to her students. She was able to practice the skill of coordinating group activities. Teaching students in small groups also resulted in a larger variety of cases being studied.

> *Even we had planned for this lesson to find the area of irregular objects like the leaf using a graph sheet. The planning of the lesson that we have done together has helped me in dealing with small groups of students using a different leaf for a different group. (Seema, Reflective memo)*

The constructivist methods had an impact on the teachers' views towards science teaching. The teachers had not expected that they would find that teaching became less work.

> *It was interesting and less burdensome for me to explain using this method as it made the children clear about the nutrients present in different food items, which they have grouped according to their own ways. (Meena, Reflective memo)*

Shanthi shared the excitement she felt when her students received her lesson well. The students had enjoyed the demonstrations she had performed in class and the visual examples enabled them to easily suggest information that needed to be represented in a chemical equation.

> *What we have planned while writing the lesson plan, all worked out systematically and I thoroughly enjoyed in teaching to the students enthusiastically...After this presentation I felt and wished to teach any concept by an activity, which leaves a cherishable moment in me. After all it makes teaching really effective. (Shanthi, Reflective memo)*

Thus, teachers' comments in this section reflect their views on teaching science, i.e., teaching science did not have to be a burdensome process; teaching science resulted in expanding the teachers' and students' comprehension of scientific knowledge and processes; teaching science using small group activities and inductive thinking was more effective (for teaching and learning).

Learning science through a constructivist approach

The teachers indicated that constructivist approaches expanded their views on the type of scientific knowledge, skills and attitudes that students could cultivate. The teachers stated that focusing on foundational concepts and drawing on students' prior knowledge was an effective means to enhance students' understanding of science. The students were also able to practice scientific skills such as observing and measuring objects.

> *During the interaction with you while planning I realized that we were concerned for those details of the lesson which are the basics, and they ought to have a clear idea of units of area like square cm. The planning of this lesson was effectively done to meet the requirements of the students and the way they would perceive things around them. The concept was made easier to the students to understand which helped them to learn by*

doing i.e. measuring areas of small objects using a square of side 1 cm. (Seema, Reflective memo)

The constructivist activities gave students the opportunity to physically engage in their learning. They were able to explore scientific ideas on their own, which facilitated higher level thinking. Rote memorization and lecture style methods provide little opportunity for such extensions.

As you have seen in my previous class, the students were anxious to know how the area of a circle is calculated. I had told them about it that, even for a circle also there is a formula to find out the area. (Seema, Reflective memo)

Meena shared how her expectations of her students' abilities to categorize similar food items and justify their categories changed. The students supported their categorizations based on their prior knowledge, even though at this point Meena had not taught the students the characteristics of essential nutrients: carbohydrates, proteins, fats, vitamins and minerals.

Actually, it became very easy for them to relate the different food items with the essential nutrients present in them. I would definitely like to continue with the inductive method for different topics in my classrooms. (Meena, Reflective memo)

Meena also made a connection between building student interest and retention of scientific knowledge.

As I strongly believe that teaching, using different activities will help in inculcating interest in children and will also provide the children with an opportunity to do things on their own, which would help them to retain and remember things more easily. (Meena, Reflective memo)

Extensive class discussion guided by students' questions and explanations is a key aspect to constructivist instruction. Shanthi identified the benefits to engaging in this activity, prior to provision of the teachers' explanation of scientific phenomena.

I also felt that use of demos makes the students involve in discussions and they learn the same moment. (Shanthi, Reflective memo)

Shanthi's lesson was an introduction to writing chemical equations. She demonstrated different reactions and asked the students to come up with word equations for the processes. Once students had shared their thoughts, she proceeded to fill in the missing information.

Although most of the lessons went as planned, there were a few that did not work as well. In Sana's lesson on microorganisms involving pond water and yogurt samples, students were not able to view the simple protozoa and bacteria due to problems with the setup.

> *Unfortunately we did not get the view of micro-organisms under microscope. It would have been the most first hand experience for the students to see the micro-organisms what they are in actual and would have been simplified their learning. (Sana, Reflective memo)*

For the following class the slides were prepared carefully with fewer quantities of the sample and indicator. The students were now able to better view the organisms. Sana recognized that giving students the opportunity to view real sample would enhance their understanding of the presence of microbes in their daily lives. Sana's explanation of the parts and functions of the microscope and demonstration of slide preparation enabled students to experience (albeit vicariously) the skills needed to conduct observations under a microscope.

In summary, teachers' comments in this section reflect their views on learning science through a constructivist approach: learning is enhanced by building a good understanding of foundational ideas and hands-on activities; learning is extended through classroom discussion and small group activities; students learn better and retain information longer when their prior knowledge and interests form the basis of instruction. The teachers' feedback on constructivist instructional methods was for the most part positive. Their reflections based on the outcomes of these lessons indicate that the lesson were effective with regards to science teaching and learning. As Marlow and Stevens (1999) found, students' interest has a significant effect on teachers' on-going use of teaching methods. It is with this hope that I left my co-participants at Princess Esin Girls' High School at the end of the TISD project.

CHAPTER 5: DISCUSSION OF RESULTS

This chapter consists of a discussion of the results presented in chapter 4. It consists of four sections, the titles of which are the secondary research questions. The chapter concludes with a found poem, drawn from the interviews with the participants.

1a) To what extent does teacher background and experience affect their use of constructivist instructional strategies?

A number of aspects of the participants' background and experience influenced their ability to plan and implement constructivist lessons. Positive experiences with school science and teaching led the teachers to choosing science and teaching as a career. Duru-Bellat (1995) cites a British study that found a rise in the enrollment of girls in secondary physics courses from 10% to 40% when students were part of a common program till age 16, which is the situation in India, followed by special courses of study until age 18. All the participants benefited from long-term exposure to science. They all had done their B.Sc. and B. Ed. degrees which gave them a solid foundation in science and mathematics, in curriculum and pedagogy. All participants stated that although they were encouraged by their parents to go into teaching it was their personal choice to study science and mathematics at the post-secondary level. The teachers and their parents view the teaching profession as being complementary to the role of being a mother and wife. Such generalizations regarding the gendered nature of work are not unique to India. Parents have a significant influence on socialization of their children into gendered roles. Children are known to associate with their appropriate gender label by age three (Farenga & Joyce, 1999). Positive attitudes towards teaching, as an appropriate career for a woman, enable the teacher to work on enhancing their practice while at school. School-based professional development would be most conducive for female teachers that have to go between their professional and personal responsibilities.

Julie Wood (2000) has shown that role models in science have a positive influence on the retention of girls in science. The participants spoke of their teacher role models as someone who

had inspired them to study science or mathematics. Past science experiences also have a powerful effect on the formation of science teaching identities (Letts, 1999). Their teacher role models had an impact on the teachers' teaching behaviors and practice. The teachers attempted to follow in the footsteps of their role models who had made science interesting for them. Sana's aspirations to be like her biology teacher made her open to professional development. Three of the participants pointed to the fact that the ability to make science or mathematics interesting was a key factor that made teachers memorable.

While formal training through educational programs set the foundations for the nature of professional practice, 70 % of what we do on the job is learned on site through informal training (Dobbs, 2000). Over time an individual's expertise in different aspects of the work grows and teachers gain confidence through experience in instructional methods, classroom management, assessment and evaluation or child psychology. Schön (1983) speaks of professional expertise as the ability to engage in reflective conversations with situations in practice. Practitioners either consciously or unconsciously participate in this process of evaluation of situations. They make decisions about the future based on these experiences, which in turn add to their repertoire of examples and increase expertise in their field. The participants were able to articulate their strengths and the areas that they wished to improve in. They were able to reflect on their practice and make necessary changes, as they had done over their first years of teaching.

These conditions made the teachers good candidates for participation in the Teacher Instructional Strategies Development (TISD) project. They were young so as not to be set in their ways or resistant to change and yet they possessed enough teaching experience to be able to identify aspects of their practice they wanted to work on.

1b) To what extent do teachers' views on science and science education (teaching and learning) affect their use of constructivist instructional strategies?

The teachers' views contain characteristics of pragmatic and realist philosophies. The teachers' views that scientific knowledge is based on facts is a realist view, while their views on science being closely tied to real life experiences subscribes to a pragmatic perspective.
The teachers' views of science, as interacting with and studying the environment, is not far from a constructivist perspective - *reality* as diverse and changing, and *knowledge* as an ongoing process of meaning-making. Their receptiveness to constructivist instructional methods is seen in their desire to design hands-on activities linked to their students' daily lives. Despite the similarities there is still a gap between their views of the scientific process and the way in which science education is implemented in their classrooms. However this discrepancy between beliefs and practice needs to be considered in light of the means and ends of the educational context in which these teachers work. By comparison to most government school in India, the facilities at PEGHS are sufficient as the teachers have access to basic resources and facilities necessary to cover the curriculum. However restricted by time, funds and professional development opportunities the teachers find it difficult to engage in innovative instruction. Further the drive to produce good results on the government exams so that their students may be successful in their future endeavors through entrance into good colleges is yet another factor restricting opportunities for teachers to experiment with diverse instructional approaches. Such internal - school-based, and external - Ministry mandated, conditions are shown to present difficulties for the teachers in the implementation of constructivist teaching methods (Chang, 1998; Ramos, 1999; Wang et al., 1999).

Pragmatic outcomes, such as make connections and apply knowledge to their daily lives, fit the objectives of a constructivist approach to science (Grennon-Brooks & Brooks, 1993). The congruence between the learning outcomes and the objectives of the constructivist lessons contributes to their successful implementation in the participants' classrooms. The teachers' outcomes closely fit features of the inquiry-based method that advocates that ample room be provided for students to discover natural laws at play in the environment. The constructivist approach differs from this approach in that it believes that knowledge is not "out there" waiting

to be discovered but is instead constructed through past and present experiences available to the student. While the teachers demonstrated a clear understanding of the outcomes of a scientific method of study they did not comment on the nature of students' prior knowledge. Studies on student understanding and constructivism show that prior knowledge plays a significant role in cognitive knowledge processes, and that it could enhance or limit how students make meaning of newly introduced science concepts (Driver, 1983; Shapiro, 1994).

The situational learning method and learning-by-doing approaches that the participants spoke of have elements of constructivism in them. However both methods are teacher-centered and unlike constructivism do not appear to address students' misconceptions prior to explanation of scientific concepts. However, if applied together they would in fact encompass the essential ingredients of Bybee's 5E constructivist model. The constructivist approach also advocates that teachers must recognize the culture clash that takes place in their classrooms and help students to make border crossings between their home cultures and the culture of science in their classroom (Aikenhead, 2001). The teachers at PEGHS fulfill their role as culture brokers when they make connections between the curriculum and the events in students' lives. Comparing their methods, such as learning by doing, questioning, use of examples from daily life and when possible hands-on activities with those suggested in order to implement constructivist science indicate that the teachers' pedagogical styles were conducive to the use of constructivist methods. Consequently they were able to successfully implement the lessons planned in the TISD meetings. Their students adapted well to these new methods as they were not too different from their teachers' existing instructional methods and they involved a hands-on approach to engage them.

The qualities and metaphors identified by the teachers could be seen in some cases describing a positivist teacher and in other cases a constructivist teacher. Characteristics such as curiosity, innovativeness, inquisitiveness, which were identified as qualities of a good science teacher are similar to those cited as learning outcomes for their students. Subject matter knowledge and organization skills were also viewed as important characteristics by the participants. These characteristics are similar to ones associated with scientists and a scientific attitude. Consequently they are more in line with a positivist approach to science instruction. Sana shared that the qualities of her teacher role model, such as approachability and friendliness, were

important if students' questions and interests were to be adequately addressed. These qualities embody a teacher who establishes a relationship with his or her students and would be able to structure teaching and learning to address the needs and interests of the students. Such a teacher fits the description of a constructivist educator (Grennon-Brooks & Brooks, 1993).

The participants' views of science, the learning outcomes they hoped to cultivate in their students, the own aspirations for improvement and growth, the nature of the teachers' existing practice and their willingness to be flexible, within their means, to ensure student understanding made it possible for them to easily implement the constructivist lessons planned over the course of the TISD project.

1c) To what extent does the school environment, including collegial interaction, affect teachers' use of constructivist instructional strategies?

A variety of factors in the school culture and environment were identified by the teachers as influencing staff and student morale. The teachers felt there was a different atmosphere at the school that contributed to a healthy teaching and learning environment, which they attributed to the good physical facilities and resources, student-teacher relationships and the staff commitment towards students' learning and the attention given to all students irrespective of their socio-economic backgrounds. Operation Blackboard launched by the Ministry of Education recognized the need to improve school facilities and resources. Although the lab facilities and school library still need to be expanded, the facilities at PEGHS are well above the minimum standard proposed by the government. The spacious and well equipped classrooms, clean and green school grounds might be considered luxurious in comparison to the bursting classrooms and small compounds of most government schools. The private funds that support the school make it easier to maintain its standard. At the same time the administration was kept accountable to the Board that monitored the use of the available and requested funds. Such an environment, with small class sizes, well-qualified and committed teachers, sufficient physical facilities (in comparison to most Indian schools) is conducive to the practice of constructivist science.

While there had not been many opportunities for external professional development the administration had set aside the third Saturday of each month for staff development. However at the time of this project there had not been an opportunity for such work due to other curricular, extra-curricular and administrative responsibilities and commitments. The teachers shared that they had benefited from sharing staff rooms with colleagues in the same subject area. Collegial conversations took place in these workspaces and also served as social settings to relax in. Common workspaces are favorable to conduct collegial discussions. In my own teaching experience I found sharing office space with colleagues in the science department useful to discuss instructional methods, assessment strategies or clarify administrative responsibilities. Sana and Seema found that they benefited from such an arrangement. Meena who shared her workspace with colleagues from different subject areas had fewer opportunities to engage in discussions centered around science pedagogy and curriculum. The extent to which the teachers discuss and share ideas about their practice is a reflection of their attitudes towards improving their practice. At the same time it is important to recognize that conceptual change in teachers typically takes place over a long period of time (Adey, 2002). By setting up co-mentoring relationships within the school or collaborative networks between schools and Universities, it might be possible to scaffold teachers as they explore the use of constructivist teaching methods (Chang, 1998; Wang et al., 1999). The teachers commented on the advantages of working collaboratively on the TISD project. Sana stated that team teaching made teachers accountable to each other and they were able to plan better lessons. Thus, students benefited from the team effort. They felt that the collaborative work enabled them to better cater to their students' abilities, while making the learning more interesting. Seema pointed out that teachers were able to generate a number of ideas for a given topic by working together. This was useful when one or the other teacher was stuck for instructional ideas on a particular topic.

Despite school specific supporting conditions there were a variety of external factors that inhibited the teachers' pedagogical growth and change. Competitive ministry examinations, a packed curriculum, a marks oriented focus, limited laboratory equipment and resources and time to work on professional development are some conditions that inhibit the use of constructivist instructional strategies. These conditions are mirrored in studies conducted by researchers in Taiwan and North America (Chang, 1998; Ramos, 1999; Wang et al., 1999).

2) To what extent does the use of constructivist instructional strategies affect teachers' views on science education?

The data collected in this research study demonstrated that the use of constructivist instructional strategies has a positive effect on teachers' views on science education. The participant teachers found that using the strategies in the TISD project and working collaboratively on lessons made teaching and learning more interesting and meaningful for both themselves and their students.

The participants commented, in their reflective memos, on how using constructivist instructional strategies had altered their views on teaching and learning science. The teachers' views about teaching science through activities changed. They had perceived that this would involve more work and were not sure if the learning outcomes for their students would be met. Not only did the teachers realize that teaching became less work but they also found themselves enjoying teaching in this way. Seema and Sana stated that the constructivist lessons were carefully planned to match students' abilities and interests. Seema pointed out that the lessons concentrated on students' understanding of foundational ideas. Meena stated that using the Inductive Thinking approach made teaching Nutrition "less burdensome". Her students were engaged and grasped the concepts easily. Shanthi felt that the lessons progressed "smoothly" when students understood concepts easily and were not confused about the material being covered. She added that it made for an "enjoyable" experience when students were eager to participate and learn more. Shanthi shared how her students requested additional material to test their knowledge on balancing equations. The students, she felt, learned faster and challenged themselves by asking for more equations to balance. Seema spoke of the questions her students asked during the constructivist lessons. The hands-on activities, to find the area of irregular shapes, provided more opportunities for higher order thinking. Consequently, they said they would continue using these teaching methods. The participants also found their own understanding on scientific knowledge improved. They recognized the truth in the phrase "when you teach you learn".

The inductive thinking activities made the teachers realize that their students possessed preconceptions about scientific concepts that enabled them to categorize items effectively. Involving students in a discussion, where they articulated their prior knowledge, was a strategy the teachers recognized as resulting in rapid comprehension of new concepts. Working with students in small groups enabled the teachers to circulate and facilitate learning better. The students who were engaged in activities, that involved manipulating objects, taking measurements and making observations, asked higher order questions and applied their knowledge to their daily lives. The teachers realized that by increasing students' interest in science they were able to better retain their conceptual knowledge. The teachers found that the collaborative effort in planning and implementing lessons that resulted in a focus on basic concepts while allowing for discussion and extension to higher levels of thinking and learning. The teachers' comments about the teaching methods specifically address the qualities of the constructivist approach. Their comments regarding the effects of the lessons on their work load, pedagogy and understanding is indicative of their shift in views about science teaching. The connections they made between the teaching methods and student learning is also indicative of their shifting understanding about what students know and how students learn.

Most of the lessons progressed smoothly. However, given that constructivist lessons required materials and equipment to be set up, there was the need to spend time gathering and testing necessary items prior to conducting the activities. This was an aspect of the project the teachers realized as essential to avoid wasting class time.

Thus, this study found that:

- Early interest in school science and mathematics, teacher role models, degrees in science and teaching were aspects of the teachers' educational background and experience that affected their receptiveness towards constructivist instructional strategies.
- Their views on the nature of science, their existing teaching methods and identified learning outcomes made it possible for them to adapt to constructivist instructional approaches.

- The positive student culture, good physical environment, collegial conversations and opportunities (albeit limited) for professional development provided a supportive atmosphere for teacher growth and change. Given these conditions the teachers were able to plan, implement and reflect on the use of constructivist instructional strategies. Factors such as lack of equipment and resources, lack of release time, packed curriculums, examination performance pressure inhibited opportunities for ongoing professional development.
- The teachers found the constructivist instructional strategies beneficial both for themselves and their students. The teachers stated that students obtained a clear understanding of foundational concepts and also asked higher order questions. Teaching became enjoyable and less burdensome. Lessons that acknowledged students' prior understanding of scientific concepts and that involved group activities resulted in effective learning experiences.

The final Chapter will discuss the limitations and implications of the study and its results.

Found Poetry

This section was added to show how interview texts can be used to provide poetic perspective. The purpose of found poetry is to attempt to draw upon the emotions entwined in field texts. Lynn-Butler Kisber (2001) speaks of found poetry as a means to extend the life of research documents while engaging in an arts-based form of critical inquiry. When asked to reflect on aspects of their practice, the teachers shared experiences that were emotionally significant.

Nice feathers

- Seema, Shanthi, Meena and Sana talking about their students

know them
thoroughly.
face reading ability

feeling happy
all your hard work
when your children do something,
on their own

so nice feathers
they participates actively,
sharing their ideas,
they answer everything,
nicely they are doing,
album of living things.

keeping in mind all the children,
so that they do it
to the maximum.
I'll be totally depressed
if they don't come out with it.
then I again work upon it
and then carry on.

CHAPTER 6: LIMITATIONS AND IMPLICATIONS FOR FUTURE RESEARCH

Journal Entry (Hyderabad, India; Sunday, November 2, 2003):
Sitting here in the departure lounge waiting to board the Silk Air flight back home (my other one ...or one among many!). Where have these past two and a half months gone? It's already beginning to feel like a dream ...something I fear, the experience losing life ...the essence, strong scent vaporizing with time ...Will the data partially protect against this, will the written analysis cement some of it? While I feel satisfied with the work done, I wonder if Seema, Meena, Sana and Shanthi will be able to say the same?

Limitations

Although writing reflective memos was one way of getting feedback from the participants, I find myself questioning the validity of the process. I wonder if the teachers felt they could be critical of what we were doing. They had been chosen by the school Director to work with me. This implied that they were committed teachers who were able to juggle a variety of tasks at school while working on the research study. The effectiveness of these methods might also be questioned in light of the desire of the teachers and students to put their best foot forward in the presence of a visitor (i.e., me the researcher). As I spent a significant amount of time at the school, I feel this performance bias was reduced as I came to be seen as a member of the school community.

The project had called for an added commitment, on the part of the teachers, amidst an already packed teaching schedule. I had done my best to encourage the teachers to share their critical comments and recommendations about the work. I did my best to assure them that changes could be made whenever possible, keeping in mind the time frame. As we got to know each other better, the teachers became more comfortable with the project, telling me when they had the time to work on lesson plans and give me reflective feedback. Such feedback resulted in scheduling changes that at times left me feeling concerned about completing the work. Sana was the first to complete planning and implementation of the three lessons we set out to do. At one point, she shared that she was willing to work on more than the three lessons. With Meena and Shanthi, we planned and implemented only two lessons. There was no time to work on a third lesson because of the schedule changes due to the Sports Day celebrations. These two teachers taught the senior

students and spent extra time helping these students. Given their teaching assignment, I wondered if they had been honest about the added responsibility of working on the project.

At the same time, I sense the sincerity of their reflections. As I was at the school for most of the workday, I got to know the teachers quite well in their working environment. Also, the teachers' choice to continue planning and implementing lessons indicated they were benefiting from the work we were doing. Their students' response and my support with lesson planning were some factors that motivated them to continue.

This brings me to the question of sustainability and whether the teachers would continue using the methods. Wang et al. (1999) and Chang (1998) found in their respective action research projects that the researcher's support had a significant impact on the use of constructivist methods by Taiwanese teachers. Once the researcher left the research site, there was a decrease in the use of constructivist methods. A variety of other factors enhanced and/or inhibited the use of constructivist methods. Ministry recommendations, examination preparation pressures, support by the school administration, availability of equipment and resources, mentoring by experienced teachers and time schedules had a significant influence on teachers adopting constructivist methods (Chang, 1998; Ramos, 1999; Wang et al., 1999). The results of the project in Hyderabad, India would likely not be very different from those mentioned by these researchers. The teachers' receptiveness was due to their realization that the methods we used made student understanding of science and teaching of scientific concepts easier. The project was supported by Mrs. Nazeer and Mrs. Anwar Jani, the school Director and Assistant Director. The teachers however were still bound by examinations, limited resources and time. The administration was taking steps to initiate on-going staff development; however, it was still to be implemented at the time of this project.

Conceptual change in teachers takes place over a period of time and is dependent on a variety of factors, as mentioned. The community at PEGHS is aware of the need for professional growth and is moving towards implementing this in their practice.

Implications

A number of factors help make PEGHS a model for girl-child education and science education for girls. Women science teachers as role models (Wood, 2000), relating scientific concepts to the students' lived experiences (Stadler, Duit & Benke, 2000; Weld, 1999; Wood, 2000), cultivation of "science sensibilities" through school science activities and science field trips (Farenga & Joyce, 1999), a supportive educational environment, caring relationships between teachers and students, setting of high standards for their students and committed teachers are some of the factors. By studying single-sex girls' schools, Colleges of Education and the Ministry of Education might be able to promote the conditions necessary to reduce the gender gap in education (see Appendix A for UNDP Literacy table 2001).

The project sprang out of questions that educators were asking about improving their practice. Science teachers and administrators at schools and science teacher educators at Colleges of Education all expressed a desire to look for better ways of teaching. Working collaboratively with the teachers at PEGHS and examining the literature has directed me to the value of collaborative networks between the different groups working on teaching and learning. For professional development to be successful, it is necessary for the different stakeholders to collaborate in identifying their problems, design their own programs to address these problems and work together to achieve the objectives.

Reform efforts implemented through a top-down procedure are rarely effective in producing lasting change. If change is to take place in classrooms and in the school setting, then programs instituting change must make these settings the locus for implementation and evaluation of professional development. School-based professional development allows teachers and researchers to converse with the situations at hand through individual reflective work and collaborative problem solving. Both teachers and researchers are able to gain a better understanding of the role of teachers and the contexts in which they work. The interest and presence of the researcher at the school is an important factor in implementation of the program for educational change. As a co-investigator, the researcher, along with the participants would be able to conduct a formative evaluation with recommendations that could be implemented

immediately. Through successive cycles of planning, implementation and evaluation, the program of change can be instituted through a collaborative effort.

Understanding teachers, their beliefs, knowledge, attitudes and skills is important in designing professional development programs for them. Understanding teaching communities in relation to the socio-cultural, historical, political and economic contexts in which they exist is also necessary. A constructivist approach to teacher development, i.e., recognizing that teachers possess pedagogical knowledge, skills and values based on their previous education and experience, needs to be studied along with its implications for educational change. Teachers form the grassroots of educational change. By understanding and supporting them, we will be able to work towards building strong educational foundations for our students.

Journal Entry (Montreal, Canada; Monday, June 14, 2004):
It's hard to believe that as I write this section I'm drawing close to the end of two years of learning and growing. The journey has been rich and engaging but also overwhelming. I have few regrets about what I have experienced and feel fortunate to have had the opportunities that have come my way. The different experiences – coursework at McGill, fieldwork in India, research assistantships and meetings with fascinating and inspiring teachers and friends have made for a completely fulfilling experience. Pieces that fit together like a puzzle, a patchwork quilt of conversations, connections and critical thinking, culminating in a degree to be used.

The project has enabled me to deconstruct my assumptions about science education and instruction in India. The science teachers I worked with have taught me that with support and resources they are motivated and competent in designing and implementing enriching science experiences for their students. I have learned from reports by experts in the field that the quest to authentically support teacher development is not unique to India. I have learned also that research needs to be informed by practice and vice versa. Doing so could result in educational change for the benefit of our students.

I have learned about the capabilities of research and the sensitivities that one needs to nurture while working with busy practitioners. The research possibility of using a variety of art-forms to obtain an understanding of social, cultural and personal perspectives has been a fascinating experience. But there are a number of questions that have sprung from these experiences, questions about power and position that enable me to participate in such educational endeavors, questions about the purpose of research, about theoretical frameworks and practical realities. Although I do not have answers, I do know it is alright to keep asking. Although there are no simple solutions, by understanding complexity we might be able to attempt an honest representation of the realities in which we live.

REFERENCES

Adey, P. (2002). The role of on-service professional development of science teachers in large-scale changes in teaching practice: A look at Britain and Indonesia. In Fraser-Abder, P. (Ed.), *Professional development of science teachers : Local insights with lessons for the global community* (pp. 158-171). New York: Routledge Falmer.

Aikenhead, G. S. (2001). Students' ease in crossing cultural borders into school science. *Science Education, 85*, 180-188.

Andrews, J. H. M., Housego, I. E., & Thomas, D. C. (1990). Effective in-service programs in developing countries: A study of expert opinion. In Rust,V. D., & Dalin, P. (Eds.), *Teachers and Teaching in the Developing World* (pp.63-81). New York: Garland Publishing Inc.

Bara, J. (1998). Colonialism and educational fragmentation in India. In Bhattacharya, S. (Ed.), *The contested terrain: Perspectives on education in India* (pp.125-161). New Delhi: Orient Longman.

Basch, L. G. (2000). *Balancing the equation*. New York: National Council for Research on Women.

Bhattacharya, S. (1998). The contested terrain of education. In Bhattacharya, S. (Ed.), *The contested terrain: Perspectives on education in India* (pp.3-23). New Delhi: Orient Longman.

Bhokta, N. P. (1998) Marginalization of popular languages and growth of sectarian education in colonial India. In Bhattacharya, S. (Ed.), *The contested terrain: Perspectives on education in India* (pp.201-217). New Delhi: Orient Longman.

Bruner, J. (1971). *The relevance of education* (pp. 20-51, 108-117). New York: W.W. Norton & Company.

Butler-Kisber, L. (2002). Artful portrayals in qualitative inquiry: The road to found poetry and beyond. *Alberta Journal of Educational Research, 48*(3), 229-39.

Butler-Kisber, L. (2001). Whispering angels: Revisiting dissertation data with a new lens. *Journal of Critical Inquiry into Curriculum and Instruction, 2*(3), 34-37.

Bybee, R. (1997). *Achieving scientific literacy: From purposes to practices.* Portsmouth, NH: Heinemann.

Chang, W.-H. (1998). *Factors impeding in-service teachers from adopting constructivist instruction approaches.* Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, San Diego, CA, April 19-22, 1998. (ERIC Document Reproduction Service No. ED419666)

Chaudhary, P. (1995). *Women's education in India*: Myth and reality. New Delhi: Har-Anand Publications.

Chokski, A. & Dyer,C. (1997). North-South collaboration in educational research: Reflections on an Indian experience. In Crossley, M., & Vulliamy, G. (Eds.), *Qualitative educational research in developing countries: Current perspectives* (pp. 246-293). New York: Garland Publishers.

Clair, R. (1995). Introduction: Birth of a project. In United Nations Educational, Scientific and Cultural Organization French Commission. (1995). *The scientific education of girls: Education beyond reproach?* (pp.1-10). London: Jessica Kingsley Publishers.

Crossley, M., & Vulliamy, G. (1997). Qualitative research in developing countries: Issues and experience. In Crossley, M., & Vulliamy, G. (Eds.), *Qualitative educational research in developing countries: Current perspectives* (pp. 1-30). New York: Garland Publishers.

Daloz, L. (1999). *Mentoring: Guiding the journey of adult learners* (p. 203-229). San Francisco: Jossey-Bass.

Damnjanovic, A. (1999). Attitudes toward inquiry-based teaching: Differences between pre-service and in-service teachers. *School Science and Mathematics, 99*(2), 71-76.

Das Gupta, U. (1998). Tagore's educational experiments at Santiniketan and Sriniketan, 1901-1941. In Bhattacharya, S. (Ed.), *The contested terrain: Perspectives on education in India* (pp.265-274). New Delhi: Orient Longman.

Davis, D., & Butler-Kisber, L. (1999, April). Arts-based representation in qualitative research: Collage as a contextualizing analytic strategy. Paper presented at American Educational Association Annual Meeting, Montreal, Quebec. (ERIC Document Reproduction Service No. ED431790)

Davis, K. S. (2002). Advocating for equitable science-learning opportunities for girls in an urban city youth club and the roadblocks faced by women science educators. *Journal of Research in Science Teaching, 39,* 151-163.

Diamond, C. T. P., & Mullen, C. A. (1999). Art is a part of us: From romance to artful story. In Diamond, C. T. P., & Mullen, C. A. (Eds.), *The postmodern educator: Arts-based inquiries and teacher development* (pp.18-36). New York: Peter Lang.

Dobbs, K. (2000). Simple moments of learning. *Training*, 37(1), 52-54,

Driver, R. (1983). *The pupil as scientist?* Milton Keynes: Open University Press.

Duru-Bellat, M. (1995). Orientation and success in the scientific streams. In United Nations Educational, Scientific and Cultural Organization French Commission. (1995). *The scientific education of girls: education beyond reproach?* (pp.65-90). London: Jessica Kingsley Publishers.

Ediger, M. (2001). *Assessing teacher attitudes in teaching science.* Missouri, US. (ERIC Document Reproduction Service No. ED 454 272)

Farenga, S. J., & Joyce, B. A. (1999). Intentions of young students to enroll in science courses in the future: An examination of gender differences. *Science Education, 83,* 55-75.

Feldman, A. (2002). Multiple perspectives for the study of teaching: Knowledge, reason, understanding, and being. *Journal of Research in Science Teaching, 39*(10), 1032-35.

Fenwick, T. (2001). Experiential Learning: A theoretical critique from five perspectives (Report No. ED-99-CO-0013). Washington, DC: Office of Educational Research and Improvement (ED). (ERIC Document Reproduction Service No. ED454418)

Fox-Keller, E. (1983). *A feeling for the organism.* San Francisco: W. H. Freeman.

Freire, P. (1972). *Pedagogy of the oppressed.* Great Britain: Penguin Books Ltd.

Fullan, M. (1993). *Change forces : Probing the depths of educational reform.* New York: Falmer Press.

Glaser, B.G., & Strauss, A.L. (1967). *The discovery of grounded theory.* Chicago, IL.: Aldine.

Government of India. (1968). *National Policy of Education.* Retrieved December 7, 2003, from http://www.ncte-in.org/pub/policy/part2_2.htm#43

Government of India. (1979). *National Policy of Education.* Retrieved December 7, 2003, from http://www.ncte-in.org/pub/policy/part2_2.htm#43

Government of India. (1986). *National Policy of Education.* Retrieved December 7, 2003, from http://www.ncte-in.org/pub/policy/part2_2.htm#43

Government of India. (1992). *Program of Action.* Retrieved December 7, 2003, from http://www.ncte-in.org/pub/policy/part2_2.htm#43

Grennon-Brooks, J., & Brooks, M. G. (1993). *The case for constructivist classrooms.* Alexandra, Virginia: Association for Supervision and Curriculum Development.

Gupta, R. P., & Hussain, A. (1998). *Issues in Indian education: A review of education, commissions, and national policies on education* (pp.44-81). New Delhi: Radha Publications.

Haney, J. J., & McArthur, J. (2002). Four case studies of prospective science teachers' beliefs concerning constructivist teaching practices. *Science Education, 86*(6), 783-802.

Hargreaves, A. (1997). Cultures of teachers and educational change. In Fullan, M. (Ed.) *The challenge of school change* (pp 57-84). Illinois: Skylight Training and Publishing, Inc.

Hobson, D. (1996). Learning with each other: Collaborating in action research. In Burnaford, G., Fischer, J., & Hobson, D. (Eds.), *Teachers doing research: Practical possibilities* (pp.93-108). New Jersey: Lawrence Erlbaum Associates.

Jaworski, B., & Watson, A. (1994). *Mentoring in mathematics teaching* (p. 124-138). Washington: The Falmer Press.

Joyce, B., & Showers, B. (1980). Improving in-service training: The messages of research. *Educational Leadership, 37*(5), 379-85.

Kamat, J. (2003a). *History of education: The agraharas.* Retrieved December 15, 2003, from http://www.kamat.com/kalranga/edu/index.html

Kamat, J. (2003b). *Tradition of women`s education in Karnataka.* Retrieved December 15, 2003, from http://www.kamat.com/kalranga/edu/index.html

Kerka, S. (1998). New perspectives on mentoring (Report No. EDO-CE-98-194). Washington, DC: Office of Educational Research and Improvement (ED). (ERIC Document Reproduction Service No. ED 418249)

Kishore, L. (2000, December). Science instruction for making children think and do. *School Science,* 38(4). Retrieved December 7, 2003, from http://www.ncert.nic.in/journal/journalnew/sschap12.htm

Kuhn, T. (1996). *The structure of scientific revolutions* (3rd Ed.). Chicago, IL: University of Chicago Press.

Kumar, D. (1998). Educational ideas of Bengali scientists from 1850 to 1920. In Bhattacharya, S. (Ed.), *The contested terrain: Perspectives on education in India* (pp.303-319). New Delhi: Orient Longman.

Kumar, N. (1998). Why does nationalist education fail? The case of Banaras from the 1880s to the 1930s. In Bhattacharya, S. (Ed.), *The contested terrain: Perspectives on education in India* (pp.83-98). New Delhi: Orient Longman.

Lave, J. & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* New York: Cambridge University Press.

Letts, W. J. (1999, April). *Teaching science/learning gender: Pre-service elementary teachers write about science, gender, and identity.* Paper presented at American Educational Association Annual Meeting, Montreal, Quebec. (ERIC Document Reproduction Service No. ED44169)

Lin, S.-W. (2002, April) *Improving science teaching through teacher development group: A case study of elementary teachers.* Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, New Orleans, LA. (ERIC Document Reproduction Service No. ED464817)

Louden, W. (1992). Understanding reflection through collaborative research. In Hargreaves, A., & Fullan, M. (Eds.), *Understanding teacher development* (pp. 178-215). New York, N.Y. : Teachers College Press.

MacKenzie, A.(2001). The role of teacher stance when infusing inquiry questioning into middle school science classrooms. *School Science and Mathematics, 101*(3), 143-53.

Maheswari, A. N. (n.d.a). *An alternative agenda for school education.* Retrieved December 7, 2003, from http://www.geocities.com/Athens/Parthenon/2686/gandhi.html

Maheswari, A. N. (n.d.b). *A programme for making education in India relevant to an information age.* Retrieved December 7, 2003, from http://www.geocities.com/Athens/Parthenon/2686/melboum.html

Maheswari, A. N. (n.d.c). *Teacher education and certification in India.* Retrieved April 10, 2004, from http://www.geocities.com/Athens/Parthenon/2686/teacher-education-certification.html

Manu's code. (n.d.). Retrieved December 15, 2003, from http://www.encyclopedia.com/html/section/Sansklit_TheVedicPeriod.asp

Marlow, M. P., & Stevens, E. (1999). *Science teachers attitudes about inquiry-based science.* (ERIC Document Reproduction Service No. ED466350)

Maxwell, J. & Miller, B. (1992). *Two aspects of thought and two components of qualitative data analysis.* Unpublished manuscript.

Maykut. P., & Morehouse, R. (1994). *Beginning qualitative research: A philosophic and practical guide* (pp. 126-149). Washington, DC: Falmer Press.

Minault, G. (1998). *Secluded scholars: Women's education and Muslim social reform in colonial India* (pp.1-57,196-214). New York: Oxford University Press.

Musnil, C. (1995). Did you say 'future engineers'? In United Nations Educational, Scientific and Cultural Organization French Commission. (1995). *The scientific education of girls: Education beyond reproach?* (pp.38-48). London: Jessica Kingsley Publishers.

Ornstein, A. C., & Hunkins, F. P. (1998). *Curriculum: Foundations, principles, and issues* (3rd Ed.). Boston: Allyn and Bacon.

Panda, P. (2001, February). Alternative paradigm towards quality teacher education: Need for collaborative change. *Journal of Indian Education*, 26(4). Retrieved December 7, 2003, from http://www.ncert.nic.in/frame.htm

Pillai, J. K., & Rajeswari, K. (1988). *Readings in women's education.* Kodaikanal: Mother Teresa Women's University.

Ramos, E. (1999, June). *Teaching science constructively: Examining teacher's issues when teaching science.* New York, US. (ERIC Document Reproduction Service No. ED436391)

Roth, W-M. (1998). Teaching and learning as everyday activity. In Fraser, B. J., & Tobin, K. G. (Eds.), *International Handbook of Science Education* (pp.169-182). Great Britain: Kluwer Academic Publishers.

Sadker, M., & Sadker, D. (1995). *Failing at fairness: How our schools cheat girls.* New York: Simon & Schuster Inc.

Sankhdher, B. M. (1998). Gandhi and the national education movement. In Bhattacharya, S. (Ed.), *The contested terrain: Perspectives on education in India* (pp. 290-297). New Delhi: Orient Longman.

Schön, D. A. (1983). *The reflective practitioner: How professionals think in action.* New York: Basic Books.

Shapiro, B. (1994). *What children bring to light: A constructivist perspective on children's learning in science* (pp. 3-19,181-200). New York: Teachers College Press.

Smith,R.L. (1997). Implementing qualitative research in Pakistan: International teamwork. In Crossley, M., & Vulliamy, G. (Eds.), *Qualitative educational research in developing countries: Current perspectives* (pp. 245-264). New York: Garland Publishers.

Sreelekha, S., & Nayar, K. A. (1998, September). The effectiveness of concept attainment model (CAM) in learning chemistry at secondary level. *School Science,* 35(3). Retrieved December 7, 2003, from http://www.ncert.nic.in/frame.htm

Srivatsava, G. (1998) The contribution of male intelligentsia to women's education in Bombay presidency during the colonial period. In Bhattacharya, S. (Ed.), *The contested terrain: Perspectives on education in India* (pp.275-289). New Delhi: Orient Longman.

Stadler, H., Duit, R., & Benke, G. (2000). Do boys and girls understand physics differently? *Physics Education, 35,* 417-422.

Stuart, J., Morojele, M., & Lefoka, P. (1997). Improving our practice: Collaborative classroom action research in Lesotho. In Crossley, M., & Vulliamy, G. (Eds.), *Qualitative educational research in developing countries: Current perspectives* (pp.162-197). New York: Garland Publishers.

Thiessen, D. (1992). Classroom-based teacher development. In Hargreaves, A., & Fullan, M. (Eds.), *Understanding teacher development* (pp.85-109). New York: Teachers College Press.

United Nations Development Program. (n.d.). *India human development statistics.* Retrieved December 7, 2003, from http://www.undp.org/hdr2003/indicator/cty_f_IND.html

United Nations Educational, Scientific and Cultural Organization. *Women watch demographics.* Retrieved December 15, 2003, from http://unstats.un.org/unsd/demographic/ww2000/edu2000.html

Walia, K., & Rajput, J. S. (2003). *Emerging priorities in teacher education in India.* Retrieved December 7, 2003, from http://www.ncert.nic.in/priorities.htm

Wang, S.-Y. P., Guo, C.-J., Chiang, W.-H., Cheng, S.-S. (1999, March). *Teaching for meaningful understanding: A school-based science and mathematics teacher development project.* Paper presented at the Annual Meeting of the National Association for Research in Science Teaching *Boston, MA.* (ERIC Document Reproduction Service No. ED429829)

Weld, J. (1999). Achieving equitable science education. It isn't rocket science. *Phi Delta Kappan, 80,* 756-758.

Wenger, E. (1998). *Communities of practice: Learning, meaning and identity* (pp 72-85). New York: Cambridge University Press.

Wideen, M. F. (1992). School-based teacher development. In Fullan, M., & Hargreaves, (Eds.), *Teacher development and educational change* (pp. 123-155). New York: Falmer Press.

Wood, J. M. (2000). The girls have it! *Instructor, 109,* 31-35.

APPENDICES

APPENDIX A:

HISTORY OF EDUCATION IN INDIA (a detailed description)

HISTORY OF EDUCATION IN INDIA (a detailed description)

India has a long and ancient history, influenced by many groups of people. These people(s) and their cultures, either indigenous or (at one time) foreign, influenced the educational framework of the country. In this section the history of education in India is traced from the indigenous systems in the ancient period to the contemporary system based on the colonial educational system.

Pre-Colonial Era (c. 1500 BC – 1756 AD)

Ancient Period (early c.1500-800 BC, late c.800 BC – 700 AD)

Different forms of schooling existed in the Indian subcontinent as far back as the ancient-Vedic period. During this era the foundations of Hinduism were laid. On account of the simultaneous establishment of the caste system, education was restricted to the upper castes: the Brahmin priests and Kshatriya warriors (Chaudhary, 1995). Women of the upper castes participated in and contributed to the various disciplines. By the end of the Upanishadic and Epic periods (c. 250BC) there was a steady decline in the participation of and access given to women in education. This trend continued as different groups came to power and few women were receiving an education after about the 6^{th} and 7^{th} Centuries (Chaudhary, 1995).

Medieval Period (1026 AD – 1756 AD)

Although women of the upper castes and royalty continued to have access to various forms of education, the Medieval period is considered the "dark period in women's history" (Pillai & Rajeswari, 1988). The position of women had begun to deteriorate by the early part of the new millenium. There was an increase in the practice of Manu's code (from the post-Vedic period) that called for women to be restricted to the domestic sphere with no property or marital rights. It also banned widow remarriages and resulted in an increase in the practices of sati, dowry and child marriage. Manu's code sought to

validate and preserve the high caste position of the Brahmins. It stated that, "A faithful wife who wishes to attain heaven and dwell there with her husband, must never do anything unkind towards him, whether he be living or dead" (Pillai & Rajeswari, 1988).

The decline in the status of women and their access to education was accelerated during the Mughal occupation on account of the widely followed practices of purdah, polygamy and child marriage. Royal harems (zenanas) housed a number of women amidst very sheltered conditions. Although there were exceptions, depending on the Emperor in power, the harem culture focused on domestic affairs. Muslim girls and women were instructed in religious matters and were taught to recite the Holy Quran by rote. Teaching women how to read and write was considered dangerous. It was widely believed that "if women had power over the written word, their capacity to disrupt men's lives would be increased" (p. 23, Minault, 1998). Minault (1998) provides the following quotation from *A Mirror for Princes: The Qabus Nama,* a Persian classic dating from the eleventh century written by Kai Kaus ibn Iskandar: "If you have a daughter...When she grows up, entrust her to a preceptor so that she shall learn the provisions of the sacred law and the essential religious duties. But do not teach her to read and write; that is a great calamity" (p.24).

There were pockets of progress: the emperor Akbar established a girls' school in his palace at Fatehpur Sikri, Muslim widows were allowed to impart instruction on the Holy Quran, instruction of girls in private homes was widely practiced (Pillai & Rajeswari, 1988). There were women poets and performers (singers, dancers, musicians). There were also women accountants, fighters and guards (typically found in the royal harems) (Kamat, 2003b). Temple sculptures depict women from the medieval period engaged in recitation by holding palm leaves-book in their left hand while playing an instrument in the right hand are a common sight in the temples of Karnataka (Kamat, 2003b). In rural areas a large portion of women formed the working class. Often hard-pressed on account of their economic circumstances, these women worked in the fields, as washer-women (dhobins) and in the houses of feudal lords (Pillai & Rajeswari, 1988).

Colonial and Nationalist Era (1757 AD – 1947 AD)

The British entered the country in the 17th Century as traders of the East India Company. They spread across the sub-continent and consolidated their rule in India over the course of the nineteenth century. During the mid-nineteenth century the seeds for the Nationalist movement were also being sown. Both colonial and nationalist camps proposed their particular ideologies with respect to the education of the masses. As members of the upper castes participated in the colonial educational system there emerged a new hierarchical structure with the formation of the middle class. Members of this newly educated class, schooled in the colonial system, were reluctant to support extension of the education programs to the underprivileged lower classes (also members of the lower castes) for fear of having to share their newly acquired educated status. S. Bhattacharya (1998) identifies two terrains on which the objectives of an educational system for India were contested.

On the first terrain nationalists criticized the colonial system of education believing that the colonial system prescribed a narrowly defined curriculum aimed solely at the "reproduction" rather than the "production" of knowledge as described by Pierre Bourdieu in his description of education in a capitalist society (Bhattacharya, 1998). A number of Indians resented having to learn British history at the cost of the knowledge of their own past (Sankhdher, 1998). Sankhdher (1998) provides a quote by educationist Radhakant Dev who described the system of education as one where people were "weaned away from the plough, the axe and the loom" (p. 293). In other words this led to the separation between education and manual labor (Bara, 1998). Another consequence of this system was the marginalization of the vernacular languages *lok basha* (used by the common person/lower castes) in favor of Sanskritised, chaste Hindi *shisht basha* (used by the middle and upper classes) (Bhokta, 1998). Bhattacharya (1998) compares the relevance of science and technology education that was initiated in the mid-nineteenth century in India to its relevance in Europe when he says: "That infusion was partly demand-led in industrializing societies and, on the supply side, science and technology was an organic growth with the European socio-cultural framework. In India there was no

such organic relationship between science-technology education and indigenous society, nor the kind of industrialization that would create demand for it." (p. 4).

Despite the lengthy criticism of the colonial system of education in India it would be irresponsible not to recognize that there was also much gained in the areas of education for the marginalized groups (women and lower castes). The British government along with the Christian missionaries spearheaded the movement for women's education. Srivatsava (1998) describes how education in the Western system produced a male intelligentsia that recognized and promoted the cause for the education and emancipation of women and lower castes. Raja Ram Mohan Roy, Ishwar Chandra Vidyasagar, Gopal Hari Deshmukh, Mahadev Govind Ranade, Maharishi Keshav Karve in their roles as politicians, social activists, lawyers and journalists were instrumental in the influencing the passing of legislation to raise the age of consent from 10 to 12 (Age-of-consent Act 1891), allow widow remarriage (Widow's Remarriage Act 1856) and calling for the establishment of educational institutions for women. J.E.D. Bethune, President of the Council of Education from 1848 to 1851, opened a school for girls in 1849, which was later extended to provide higher education of women (Srivatsava, 1998). The number of girls attending primary schools rose three-fold from 1901-1921 and more significantly the number of women teachers rose more than eightfold in 40 years, from 515 (1881-2) to 1412 (1901-02) to 4,391 (1921-22), a key aspect in making schools accessible for girls (Pillai & Rajeswari, 1988)

The second terrain of contestation consisted of the ideological battles between different groups of Indians in their respective visions for an independent country. One battle was that between the newly formed educated middle class (*bhadralok*) and the proponents of popular education. The bhadralok was predominantly made up of members of the higher castes who had been educated in English schools. When the British government proposed schemes for popular education in the late-nineteenth century it encountered resistance from members of this class. They feared loss of their high social status and age-old favor in the government due to the possible upward mobility of the lower classes through education (Bara, 1998). The other prominent conflict was between those who believed in

a "synthesis" of the colonial and nationalist systems of education and those that felt the urgency of a more indigenous system of education. Uma Das Gupta (1998) addresses this issue in her article where she compares and contrasts Tagore's educational ideologies with Gandhi's. Although the basis of the ideologies of both leaders was to promote a form of education to uplift India's vast illiterate and under-privileged population, their approaches were different. Tagore's ideology drew on the strengths of Indian classical traditions as well as European knowledge to educate students. Gandhi proposed the Wardha scheme which rejected the colonial system of education, accusing it of isolating the lower classes by replacing Indian languages by English as the medium of instruction. His scheme favored indigenous knowledge and skills. As the popularity of Gandhi's ideology grew, students and teachers boycotted English schools and universities in favor of national schools and colleges established in Poona, Ahmedabad, Lahore and Patna (Sankhdher, 1998).

Post-Colonial Era (1947 AD – present day)

It was on the foundations of this long and colorful history that the newly appointed independent Government of India had to construct its educational policies. The task was a daunting one given the diversity in culture that existed across the nation. It continues to be one that is grappled with in all areas, especially that of girl child education, education for marginalized groups (scheduled castes & tribes - certain socially and economically disadvantaged groups), teacher development and curriculum reform. The Indian Ministry of Education set about addressing these issues through its National Education Policies.

The current system of education consists of 10+2+3 years of schooling, as proposed by the Kothari Commission on education and endorsed by the National Commission on Teachers-I (1983-85) (Gupta & Hussain, 1998). The first 12 years make up regular school education where the first 10 years consist of a general curriculum followed throughout the country with regional information included in particular subjects (Social Studies, Environmental Science, Regional languages). The following 2 years form the higher secondary stage where students diversify into subject groups in line with future

educational goals. The final 3 years make up the first degree program in higher education. The governing bodies instituted by the Ministry of Education to oversee the organization, management and development of different facets of education in the country are at the national level the National Council for Education Research and Training (NCERT) and National Council for Teacher Education (NCTE). At the state level the State Council for Education Research and Training (SCERT) orchestrates a variety of different committees overseeing education. Education policy and issues have also been addressed in the Five Year Plans crafted by the Indian government since independence. The Education Commissions (instituted by the Ministry) drafted the National Policies on Education (NPE) in 1968, 1979, 1986 and the Program of Action in 1992 (as a review of the situation following NPE 1986). A brief note on the focus of each NPE and the Program of Action 1992 follows.

National Policy on Education (1968)

The key purpose of the first National Policy on Education (NPE) was to foster a sense of common citizenship and strengthen national integration in independent India. It proposed that free and compulsory education be made available to children up to the age of 14 years, a three language formula be adopted in the country, a nexus between school and community be created as a means of mutual support and service, the quality of textbooks be improved, the reliability and validity of examinations be enhanced, part-time education and correspondence course options be developed and promoted, measures be taken to educate adults in commercial and industrial sectors and sports education be encouraged (Government of India,1968). With regards to teachers, the NPE recognized the significance of a teachers' personal quality and character and stated that teachers be accorded an honored place in society. Consequently it proposed that their emoluments and service conditions correspond to their qualifications and responsibilities. It also identified the importance of the academic freedom of teachers to participate in further studies and research (Chaudhary, 1995). It stressed the need for the education of girls not solely on grounds of social justice but also as a key aspect towards social transformation. NPE (1968) clearly identified science education as crucial in accelerating the growth of

the national economy. It stressed that science education form an integral part of general education to the end of the school stage. Thus we see that this first policy on education in India had identified the key areas requiring attention and sought to bring about change through its different proposals.

National Policy on Education (1979)

The second policy aimed to foster the growth of the individual through a just and truthful life by inculcating the ideals of freedom, equality and social justice. While reiterating the key features of the first policy it laid emphasis on the inclusion of Socially Useful Productive Work (S.U.P.W.) and moral education. It gave high priority to the expansion of elementary and adult education. During the elementary years it sought to instill in students a scientific temper, which Chaudhary (1995) identifies as one that "gives [students] the capacity for self-criticism and a liberal human outlook" (p.35). It introduced vocational education (agricultural and farming technology) in secondary education in conjunction with the study of its related science. Once again it called for special attention to be given to girl child education and those from scheduled castes and tribes. As part of its focus on adult education in order to tackle the high percentage of illiterate adults it identified the need to appoint women instructors to teach courses on family planning, health and nutrition and mother and child care (Chaudhary, 1995).

National Policy on Education (1986)

This policy was significant in that it aimed at structural change to the existing system to facilitate proximity between the social environment and the student as well as between the curriculum and social reality. It sought to improve the quality of educational institutions by making each autonomous and more accountable. It proposed to do this by disaffiliating colleges from universities, creating a network of non-formal learning systems at different stages, dispensing with polytechnics and establishing institutes to be run by industries and the rural rich in villages areas and instituting three examinations at Class VI, VIII and X (Government of India, 1986). The policy, which was divided in to

eleven parts, dealt with women's education in detail in part IV, the section on education for equality. It called for the empowerment of women through increasing their participation in vocational, technical and professional education particularly in non-traditional occupations as well as in existing and emerging technologies. Women's Studies courses were to be offered in various higher educational institutions. Day care areas *(Angan-wadis)* were to be set up for girls who were entrusted with the care of siblings so that they could attend classes during the day. Part VIII, which focused on content, discussed the significance of science education, while part IX, dealt with strategies to make teacher training institutions more functional (Chaudhary, 1995).

Program of Action 1992 and Teacher Education

This report set forth modifications and recommendations based on the implementation of NPE (1986). While it concluded that no revisions were necessary with respect to NPE (1986) it proposed to significantly reformulate the Program of Action 1986 (Government of India, 1992). The document, while acknowledging the significance of the teacher, recognized the need to improve working conditions and quality of pre-service and in-service programs that directly affect teachers' performance. The report recognized that significant advances had however been made in the area of teacher education. In 1987 a centrally sponsored scheme *Mass Orientation of School Teachers* was launched which extended over the period of 1986-89. This resulted in 1,762,000 teachers getting training on the main priorities and directions of NPE 1986 as well as strategies for improving their professional competence. Also the Special Orientation Program of Primary Teachers ran from 1994-1997. This program was conducted by the District Institutes of Education and Training (DIETs) overseen by the State Councils for Education Research and Training (SCERTs), whose purpose was to provide academic and resource support to elementary and adult educational systems and to engage in action research and innovation in these areas. The Special Orientation Program provided training in the use of Operation Blackboard (launched to improve the quality of primary schools through the provision of adequate physical facilities and resources) materials along with orientation towards the Minimum Levels of Learning strategy which focused on teaching of language,

mathematics and environmental studies. Further the Program of Action 1992 envisaged statutory and autonomous status being conferred on the National Council for Teacher Education which came about in 1995 with the formulation of the Education Act 1993 (Government of India, 1992). Walia and Rajput (2003) provide the following table reflecting the initiatives undertaken in the field of teacher education and development:

Table 1. Progress on teacher education schemes

Sl	*Item*	*Target*	*Achievement*
1	Program for Mass Orientation of School Teachers (1986-90)	2.0 million teachers	1.76 million teachers
2	Establishment of D.I.E.Ts*	425 by the end of VIII plan (1997)	442
3	Upgrading of Secondary Teacher Education Institute into CTEs/IASEs**	135	110
4	Strengthening of SCERTs	All SCERTs (29)	20
5	Special Orientation Program of Primary Teachers during 1993-97	1.8 million teachers	1.0 million teachers

(As on 31st March, 1998)

* D.I.E.Ts – District Institutes of Education and Training

**IASE – Institute for Advanced Studies in Education

**CTE - Colleges of Teacher Education

From this table we see that teacher training has been planned and implemented quite successfully through the initiatives of the NCTE. However it remains to be seen whether the training and support provided has actually resulted in pedagogical change and student retention and achievement.

In the fifty-six years since gaining independence strides have been made towards offering quality education to all, but much more remains to be done. The United Nations Development Program (n.d.) reports the following statistics on education in India:

ADULT & YOUTH LITERACY RATE	
Adult literacy rate (% age 15 and above), 1990	49.3
Adult literacy rate (% age 15 and above), 2001	58.0
Youth literacy rate (% age 15-24), 1990	64.3
Youth literacy rate (% age 15-24), 2001	73.3
Children reaching grade 5 (%), 1999-2000	68
FEMALE LITERACY RATE (comparative ratios)	
Female adult literacy rate (% age 15 and above), 2001	46.4
Adult literacy rate (female as % of male), 2001	67
Female youth literacy rate (% age 15-24), 2001	65.8
Youth literacy rate (female as % of male), 2001	82
Ratio of girls to boys, in primary education, 1990-91	0.71
Ratio of girls to boys, in primary education, 2000-01	0.77
Ratio of girls to boys, in secondary education, 2000-01	0.66
Ratio of girls to boys, in tertiary education, 2000-01	0.61

The above rates and ratios indicate the progress that has been made over the last decade. The adult literacy rate rose by 8.7% (from 49.3% to 58.0%) and youth literacy went up by 9% (from 64.3% to 73.3%). However the reported percentage of female adult literacy to male is 67% and that of female youth literacy to male is 82%. We see as well the attrition of girls in comparison to boys in the decreasing ratios, from primary (0.77) to secondary (0.66) to tertiary (0.61) education. These statistics direct us to the work needing to be done to improve overall adult literacy rate, the unequal ratio of females to males in education and the decline in the participation of girls from primary to tertiary education.

APPENDIX B:

CERTIFICATE OF ETHICAL ACCEPTABILITY AND CONSENT FORM

INFORMED CONSENT FORM TO PARTICIPATE IN RESEARCH

This is to state that I agree to participate in the MA (Thesis) research project entitled:

Conversations, connections and critical thinking: **Collaborative action research with women science teachers in India.**

Conducted by: Anjali Abraham, McGill University

1. **Purpose:** The current state of education in Hyderabad, India is based on traditional teaching methods, but in many teaching circles there is a desire to look for innovative and cost-effective tools to improve instruction within their present curricular framework. The purpose of this project is to collaborate with a group of the teachers from the Princess Esin Girls' High School in the city of Hyderabad to identify the relationship between participation in the Teacher Instructional Strategies Development (TISD) group and the implementation of new instructional strategies (IS) in a single-sex girls' classroom. An anticipated result of this project is the establishment of a model for sustained professional development. The instructional strategies to be used by the participants will be based on the educational ideology of constructivism. The format for the TISD group will be based on the ideologies of mentorship and situated learning (Lave & Wenger, 1991).

2. **Procedure:** This project will be conducted between August 2003- October 2003 of the 2003-2004 school year (3 months) with three or four Grade 6 to 8 physical science teachers. Teachers will be assigned to the Teacher Instructional Strategies Development (TISD) group based on a volunteer basis. The researcher will conduct a baseline interview before implementation of the TISD group begins. The researcher will assess teacher instructional methods based on the 5E (Engagement, Exploration, Explanation, Elaboration, Evaluation) model, developed by Bybee *et al.,* (1989). During the group sessions, a lesson plan based on constructivist science instruction will be modeled by the researcher. This is in the hope that it will enable the teachers to identify aspects of constructivist instruction. The TISD groups will subsequently work together to modify IS conducive to their classrooms, review previously implemented lessons and plan following lessons. TISD group meetings will be recorded and classroom observation notes will be maintained. The researcher will maintain a research journal as part of the study. The participating teachers will be interviewed in the final weeks of the study to investigate the relationship between participation in TISD group and implementation of IS. An initial presentation of results will be made to the teachers, school Director and Board of Trustees prior to departure from the field. They will be used as part of the researcher's MA thesis and may form part of journal articles or conference presentations.

3. **Conditions of Participation**: The participants will have to be willing to attend weekly TISD group meetings (2 hours/week). They will have to be willing to be interviewed twice in the course of the 3-month period and to have the group meetings tape-recorded. The participants will have to be willing to allow the researcher into their classrooms to observe the implementation of the discussed instructional strategies. This is in the hope that the classroom information gathered would provide data for the formulation of results, while providing data for continued discussion in the TISD group meetings. All information gathered will be kept confidential by assigning pseudonyms along with careful organization and storage of data both at the school, McGill University and at the researcher's residence while in the field.

4. I, the undersigned,

- understand the purpose of this study.
- understand how confidentiality will be maintained during this research project.
- understand the anticipated uses of data, especially with respect to publication, communication and dissemination of results.
- understand that I am free to withdraw at any time from the study without any penalty or prejudice.

I have carefully studied the above and understand my participation in this agreement. I freely consent and voluntarily agree to participate in this study.

Name (please print) _____

Signature_____ Date_____

APPENDIX C:

INTERVIEW QUESTIONS

Interview Questions:

Conversations, connections and critical thinking: **Collaborative action research with women science teachers in India**

A) Background Information:

1. **Could you tell me about your current position in the school?** (How long have you been teaching? What subjects are you teaching and have you taught? How many students are in your class? What are your responsibilities as a classroom teacher?)

2. **I am interested in your educational background. Could you tell me about how you started out?** (What type of school & science curriculum did you experience? What degree/qualifications have you obtained to teach science?)

3. **Could we talk a little about how your interest in science developed?** (What or who influenced your decision to choose to study science?)

4. **Would you be able to explain what some of the factors were that lead you into teaching?** (Was it on account of your interest? What experiences/exposure to teaching have you had that sparked your interest? Did your peers, family, social conditions influence your decision? If yes, please describe.)

B) Views of science & science education

5. **How would you describe/what comes to mind when you think of the term 'science'?** (What processes, attitudes, skills, knowledge do you associate with practicing science?)

6. **How would you compare the science that is taught in your classroom to the science practiced in the world outside the classroom?**

7. **How would you describe the prescribed science curriculum in terms of addressing the needs and interests of the students? The needs of society?** (as teenagers, **girls**, Indian, Muslim, living within a complex local and global society)

8. **Would you be able to identify three things that you'd like your students to have learnt when they leave your classroom at the end of the school term?**

C) Views on school science (instruction) and teaching experience

9. **Do you feel your Teacher Education program prepared you to go into teaching? Please describe how it did or did not prepare you.**

10. **Could you describe some teaching methods you use?** (For instance, to teach a concept such as 'Energy'?; lecture, notes, demos, projects, field trips, videos, labs; What are the instructional resources available to aid you?)

11. **Has the way in which you teach changed over the course of your career? Would you be able to expand on why it has or has not changed?**

12. **In your experience does collegial interaction (formal and informal) play a role in your teaching practice?** Please describe how it does or does not.

13. **What in your opinion are some qualities of a good science teacher?**

D) Views on students and gender

14. **How would you describe the students that you teach?** (With respect to their interest in science & academics, their socio-economic status, their cultural influences)

15. **Would your teaching change if there were boys in your classroom? If yes, describe how.**

16. **Do you feel that your methods of instruction address your students' needs? (as teenagers, girls, Indian, Muslim, living within a complex local and global society) If yes, describe how.**

17. **Do you think that being a woman has made a difference to what you bring to your profession and for your students? If yes, describe how.**

Other:

18. **What do you find rewarding about your job? What are some challenges that you associate with teaching? What are some things that in your opinion would help you in your teaching practice?**

19. **What are some things you hope to achieve through your participation in this group?**

20. **How do you think your students will respond to you experimenting with different instructional strategies?**

21. **Do you have any questions about this project? Is there anything you feel that I haven't covered that you would like to add?**

Concluding comments:

Thank you for taking the time to participate in this interview.

APPENDIX D:

LESSON PLANS

Lesson Plan

Topic: Balancing a chemical Equation
Subject & Standard: Chemistry - Standard 7

Activity: 5 E Model

Learning Objectives
S.W.B.A.T...

- understand the relationship between conservation of mass
- balance the equation!

Materials
- Paper/match stick
- Weighing scale / balance

Activity/ ~Time	What is the teacher doing?	What are the students doing?
(A) Recapitulation	1) Teacher uses an equation to review the concept of a chemical equation	• Students volunteer answers and ask questions
(B) Understanding of mass and [ ] (C)	the relationship between conservation equation.	
	2) Teacher demonstrates "conservation of mass" by burning a piece of paper.	• Students observe, ask questions / volunteer responses
	a) What did you observe taking place?	
	b) Was the paper been destroyed? Explain why or why not?	
[ ]	3) Teacher relates conc. of mass idea to beginning example:	• - as above -

$NaCl + AgNO_3 \rightarrow NaNO_3 + AgCl$

[i.e. "conservation of total # of atoms of an element"]

a) What happened to the reactants in this Reaction?

b) How do you know that matter was not destroyed?

(1)

Activity/ ~Time	What is the teacher doing?	What are the students doing?
	c) How does the # of atoms of each element (on either side) relate to the 'law of cons. of mass'?	
[EXPLAIN] (4)	5) Teacher elaborates by explaining the need to balance equations.	• Students take notes / Ask questions
	[4) How many atoms of (Na) are there on each side? " " " " (Cl) " " " " " ? Similarly for Ag, N & O ≈]	
[ELABORATE] (6)	6) Teacher presents a 2nd example: When $FeSO_4$ and NaOH react $Fe(OH)_2$ and Na_2SO_4 are formed.	• Students take notes / ask questions
	a) Write the corresponding chemical equation	∴ $FeSO_4 + NaOH \rightarrow Fe(OH)_2 + Na_2SO_4$
	b) Create a tally table for the # of atoms of Fe, S, O, Na & H present on each side.	Fe = Fe = S = S = O = O = Na = Na = H = H =
	c) What needs to be done to ensure that the law of cons. of mass (atoms) is satisfied?	→ Teacher explains the need to "add molecules" rather than individual atoms → Teacher also explains the difference between the subscripts numbers and the number in front of the compound
Notes:		
[EVALUATE] (7 & 8)	7) Teacher provides some equations for students to practice balancing.	• Students practice / clarify doubts
	8) Teacher assesses student understanding with the following questions:	• Students (2) volunteer suggestions / answer questions
	a) Explain how balancing of eq^ns is based on the Law of Cons. of Mass	
$2H_2 + O_2 \rightarrow 2H_2O$	b) What is the significance of the different 2's in the given eq^n ?	

Lesson Plan

Topic: Measurement of area of a regular surface
Subject & Standard: General Science - Class 6

Activity: 5E Model

Learning Objectives
S.W.B.A.T...

- identify the relationship between length, width and area
- apply the formula for area to squares and rectangles
- identify that different shapes can have the same area

Materials
- Glazed papers
- 9 square centimeter pieces / student

Activity/ ~Time	What is the teacher doing?	What are the students doing?
R) Recapitulation	① a) Teacher asks questions to review concept of area studied in previous class. b) Teacher goes over areas of household items	• Students a) respond to the teachers' questions and b) present their homework results
homewk →		
[ENGAGE]	② Glazed (Folded) Paper Activity: [Rectangle] a) Teacher asks the students • to count the total number squares • to count the number of squares along the length and the width as • What mathematical operation relates these dimensions to the area?	• Students observe / Ask questions / Volunteer responses

1

Activity/ ~Time	What is the teacher doing?	What are the students doing?
	b) Teacher repeats the activity with a 2nd Square (folded) sheet	
[EXPLORE]	③ Same area, diff. figures activity (P.T.O): • Teacher provides instructions for the activity. • Teacher ensures that all students are working in pairs or trios.	• Students work (IN PAIRS) together to build squares and rectangles of a given area
[EXPLAIN]	④ Teacher asks students to present their conclusions and uses their examples to highlight the formula Area = Length × Width	• Students write their answers on the black board, explaining how they got them.
[ELABORATE]	⑤ Teacher extends the concept of areas to include those of irregular shapes	• Students listen to the teacher and ask questions
[EVALUATE]	c) a) Teacher goes over the concluding questions in the activity	• Student volunteer responses and make a note of the homework.
Homework	b) Teacher asks students to measure the dimensions of items in last class' activity	
Notes:		

Same Area, How many different figures?

1. Working in pairs (or trios), put your square cm pieces together, build as many squares and rectangles of different dimensions (length and width) as possible.
2. Draw out the two tables in your notebooks.
3. Record the different values along with the appropriate units, in the tables.
4. After completing the activity answer the following questions:

a) What is the difference between a square and a rectangle?

b) How many different shapes can be built for a given area?

A) Squares Table:

Length (in cm)	Width (in cm)	Area of the Square (in sq. cm)
		9 sq. cm
		16 sq. cm

B)

Length (in cm)	Width (in cm)	Area of the Rectangle (in sq. cm)
		8 sq. cm
		18 sq. cm

APPENDIX E:

BYBEE'S 5E MODEL INDICATORS

Table1. The participant teachers' teaching strategies during the research

Stage	What the Teachers Do	Fall 2000	Jun 2001
Engage	· Creates interest	2	4
	· Generates curiosity	2	4
	· Elicits responses that uncover what the students know or think about the concept/topic	2	1
	· Explains concepts	2	1
Explore	· Encourages the students to work together without direct instruction from the teacher	1	3
	· Observes and listens to the students as they interact	3	3
	· Asks probing questions to redirect the student's investigations when necessary	1	2
	· Provides time for the students to puzzle through problems	2	2
	· Acts as a consultant for students	1	3
	· Tells or explains how to work through the problem	4	1
	· Leads the students step-by-step to a solution	4	1
Explain	· Encourages the students to explain concepts and definitions in their own words	1	3
	· Asks for justification (evidence) and clarification from students	1	2
	· Formally provides definitions, and new labels	3	4
	· Uses students' previous experiences as basis for explaining concepts	1	4
	· Neglects to solicit the students' explanations	3	1
Elaborate	· Expects the students to use formal labels, definitions, and explanations provided previously	1	2
	· Encourages the students to apply or extend the concepts and skills in new situations	1	2
	· Reminds the students of alternative	1	1
	· Refers the students to existing data and evident	1	2
	· Lectures	3	1
	· Leads students step-by-step to a solution	3	1
Evaluate	· Observes the students as they apply new concepts and skills	2	3
	· Assesses students' knowledge and/or skills	1	2
	· Looks for evidence that the students have changed their thinking or behavior	2	1
	· Allows students to assess their own learning and group-process skills	0	2
	· Asks open-questions	1	3
	· Tests vocabulary words, terms, and isolated facts	4	1

Ps.: Mean that is inconsistent with suggested strategies

1:Almost Never (1%~20%) 2:Seldom(21%~40%) 3 Sometimes (41%~60%)

4 Often(61%~80%) 5 Almost Always(81-100%)

APPENDIX F:

TISD GROUP OBJECTIVES

AND OUTLINE FOR THE REFLECTIVE PROCESS

Fall 2003

Teacher Instructional Strategies Development (TISD) Group Outline

Description

The purpose of these sessions is to collaboratively work on developing instructional strategies conducive to the Indian classroom, in an all girls' high school. Constructivist educational ideology (Bybee, 1997; Driver, 1983; Grennon-Brooks & Brooks, 1993) proposes that by first acknowledging students' prior knowledge of scientific concepts a teacher may build on and extend their understanding of these concepts, resulting in a lasting and valuable educational experience. In the course of these sessions we will explore the use of classroom demonstrations, labs and activities with this student-centered constructivist focus. Using the constructivist perspective we will look at ways to extend student understanding of scientific concepts, through critical thinking & questioning, in our planned science activities and instructional strategies (concept maps, concept attainment & inductive thinking).

A parallel purpose of these sessions is to participate in a co-mentoring format for professional development by considering our own teaching backgrounds and beliefs while sharing with and learning from our colleagues (Fullan, 1993; Lave & Wenger, 1991). By engaging in reflective journal writing, reading & responding to professional articles, observing and/or team-teaching, it is the hope that participants will extend their theoretical pedagogical knowledge while engaging in the practical pedagogy of constructing and implementing lessons.

Some of the key objectives of these sessions are:

- To work collaboratively to create and implement science instructional strategies based on a constructivist ideology
- To identify factors that enhance the implementation of new instructional strategies in the science classroom
- To participate in a model of co-mentorship & professional development

Some of the anticipated outcomes that encompass these objectives are:

- Development of a collection of activities for the science classroom
- Formation of an instructional strategies group as a means for professional development
- Experience in a model of reflective practice

TISD Workshop: The Reflective Process

One of the goals of this workshop is to participate in a reflective process. We will engage in such a process through three different on-going activities: Identity Memos, Reflective Memos and Journal Writing.

Identity Memos

In our first session we will take some time to reflect on who we are and what beliefs we bring to our professional practice as educators. The purpose of this activity is to understand how our own identities and experiences affect and shape our practice. By engaging in this activity we might see that, as with ourselves, our students bring into the classroom their own beliefs, experiences and understandings of the world, which influence the way in which they make meaning of their classroom experience.

As you reflect on your identity memo you are welcome to present your thoughts either in text form: short essay, poetry, song, or other visual/art forms such as: collage, drawing/painting, dance performance etc. Some questions that you may use to provide you as a basis are:

- Who am I?
- Who am I as a teacher?
- Why did I choose to pursue teaching/teaching science?
- What beliefs do I bring to teaching (about education, learning, students, science etc.)?
- How might these beliefs impact my work? (think of both positive and negative ways)?

Reflective Memos

At the end of each of our sessions (planning and implementing constructivist lessons) we will take a few minutes to step back individually and reflect on the session. Some questions that you may use to guide you as you write down your thoughts:

- What were some things that stood out to me today? (an idea, a concept, a comment etc.)
- What did I learn about teaching and/or learning?
- What did I learn about working with my colleagues?
- What are some concerns/questions I have?

Journal Writing

As we work together to plan and implement the instructional strategies, it might be helpful to maintain a journal. In the journal you may want to record your thoughts and reactions to the lessons you have taught, based on the instructional strategies discussed in our group sessions. Some questions that you may use as a guide to your journal writing:

- How do I feel about the lesson taught?
- Was using this strategy more useful/less useful than how I normally teach this concept?
- What were some good features? What were some features that I would like to change?
- How were my students responding to the strategy being used?

APPENDIX G:

TEACHERS' REFLECTIVE MEMOS

Reflective Memo

SHANTHI

Name:

Date: Oct. 22

concept : writing chemical equation.

Dear Anjali,

What we have planned while writing the lesson plan, all worked out Systematically and I thoroughly enjoyed in teaching ~~to~~ the students enthusiastically. I really like your concern which you show to others, when you work in a group.

I also felt that use of demos makes the students involve in discussions and they learn the same moment.

After this presentation, I felt I wished to teach any concept by an activity & which leaves a cherishable moments in me.

After all it makes teaching really effective. Thankyou for inculcating this Interest in me.

Reflective Memo

Name: MEENA

Date:

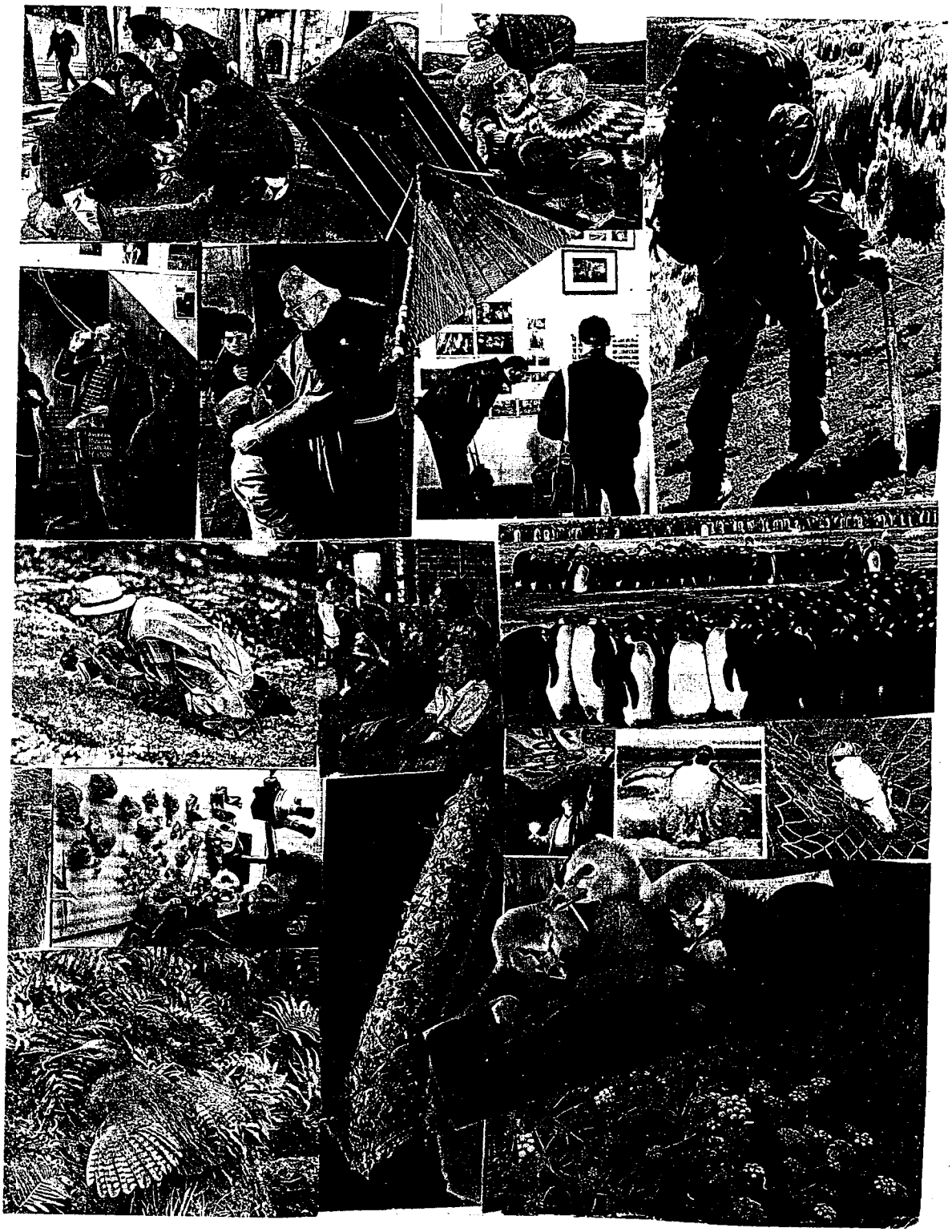
The session of planning out the lesson sitting together was very interesting and important as we got down to the level of the students and worked out different activities according to the way they would pursue things, which can also help them to identify things on their own and classify them according to their own experiences.

One important thing that I have noticed during this session was we were just concerned about making the concept easier for the children to understand by allowing them to learn something by doing practically.

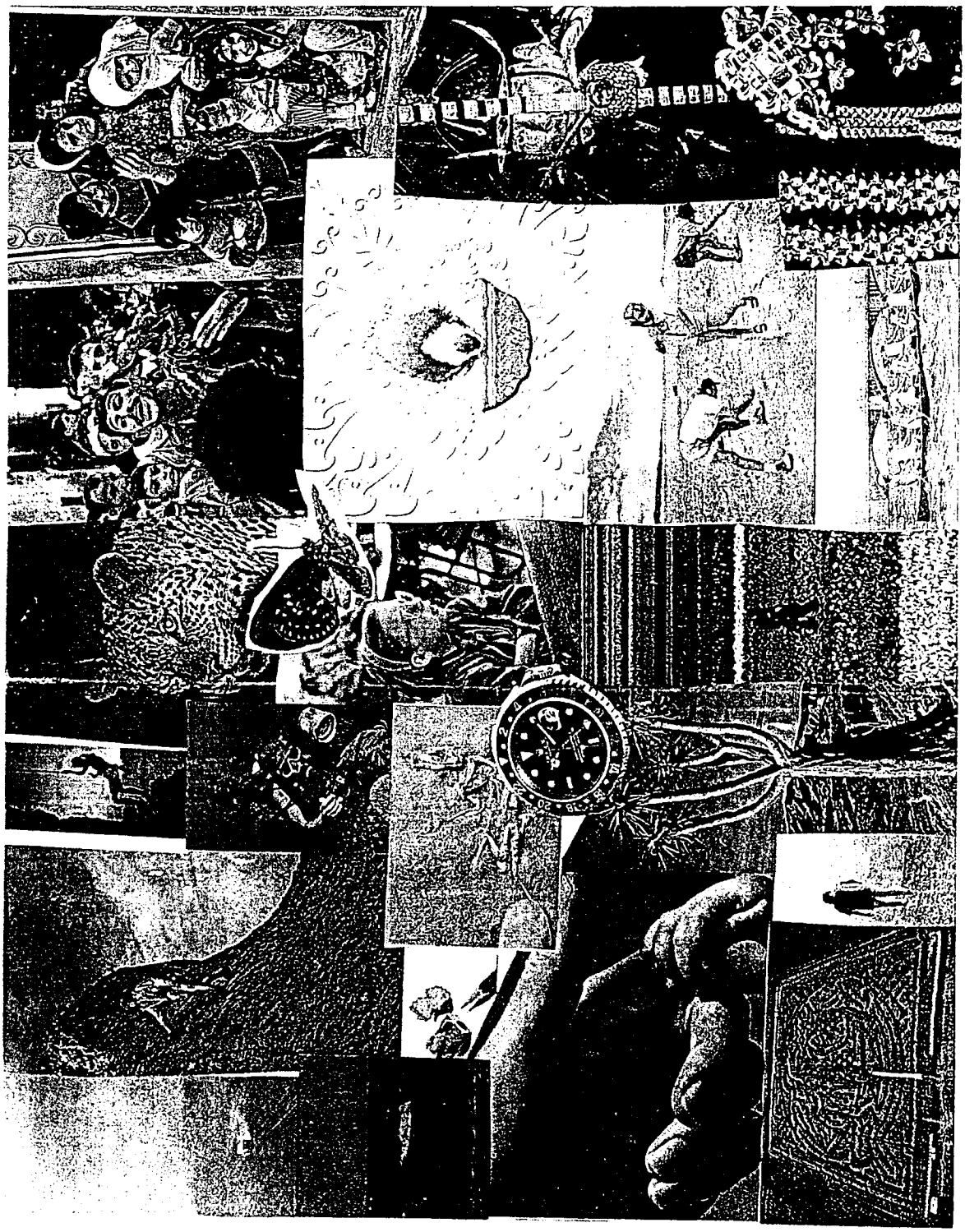
Working with colleagues is always beneficial as we can share our teaching experiences and the classroom learning outcomes which would definately make our teaching more effective.

APPENDIX H:

TEACHERS' COLLAGES



SEEMA'S COLLAGE



SANA'S COLLAGE

SHANTHI AND MEENA'S COLLAGE