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Action research for female science teacher development: Case Pakistan

Harcharan Pardhan

Aga Khan University, Institute for Educational Development, Karachi

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Dr. Harcharan Pardhan
Assistant Professor
Aga Khan University –Institute of Educational Development
Karachi, Pakistan

In Pakistan studies paint a grim picture of teacher knowledge base and classroom practice in general, and science education in particular. Across the country the school teachers at elementary level are predominately females. Majority of these teachers come with "little science educational experience and many of them openly acknowledge a fear of science" (Zahur, 2002). Having worked as a teacher educator in Pakistan since 1994 I have had similar experiences while interacting with science teachers. My experiences reveal that female teachers at various levels seem to have developed anxiety for science and are apprehensive of science for socio-culture reasons. As a result these science teachers' academic growth is restricted. However, working with the teachers and jointly engaging in discussions and critical reflections on the teaching and learning of science I have come to believe that these teachers have the potential to grow and are willing to commit themselves to make a change given the opportunity and appropriate support. This article describes a collaborative field-based female science teacher development project in Pakistan. The focus of the article will be the experiences of three female teacher participants and a female university researcher as they engage in collaborative discussion and critical reflection on teaching science in a cultural context which traditionally has not supported such interactions, especially to develop a community of learners. It is my under pinning assumption that community of learners approach to science teacher development in general and female teachers in particular has potential to expand opportunities for the teachers for personal and profession growth to become more effective science teachers and teacher educators. The action research project described in this article emerged out of my(researcher's) interactions with female science teachers in Pakistan where I had worked for the past ten years at AKU-IED as a faculty to bring about improved teaching practices among teachers in general and science teachers, male and female, in particular from different parts of Pakistan. The project focused on the question of 'how science teachers' pedagogical content knowledge can be enhanced in a way that will prepare them to develop knowledge, skills, and attitudes to promote science education. To begin with I wish to describe the context of the research project.

The Project Context

Since its independence, Pakistan has struggled to keep pace with the changing world. Its heavily centralized curriculum and prescribed textbooks have remained the same since early 80s. Science education though perceived as means for social, economical development and growth has been made compulsory for classes 1-10, however its process is predominately static and rigid. The focus is on instrumental (rote) learning rather than relational; problem solving and critical thinking (Skemp, 1986). Pakistani educators have described the learning outcomes as, "children do learn, but it is not known what they learn is useful in to-day's modern society" (Hoodbhoy, 1998:110)," and teacher education as, "the courses have been described by the student teachers as only vaguely relevant to the work they have to do in school, and the use of the lecture method seems to be in universal use in colleges of education" (Kizilbash cited in Hoodbhoy, 1998:110). Pakistan with literacy rate of only 35% (World Bank, 1993) has one of the worst records in terms of the education of its children (Business Record, 10.1.1993). Undoubtedly, science holds relationships with technology and society locally and globally. Pakistan needs to modify its curriculum and consequently teacher development in to-day's technological and Information era, to help students (male and female) gain decision-making skills and requisite knowledge necessary to be employable and effective citizens in society. Learning thus is not a matter of passively taking 'static' information but active construction of knowledge. The teacher must be a bridge between the formal knowledge of subject and the past experiences and personal purposes of their students. What it means to teach is then a complex activity and to understand the associated complexity of teachers' professional knowledge requires specialized teacher knowledge; the pedagogy of knowledge. This knowledge has to be 'experiential' rather than technical (traditional). Recently teacher educators: Osaki, 1990; Kagan, 1992; Von Glasersfeld, 1995; have challenged the traditional teacher education. They have argued that traditional educational programs generally fail to prepare prospective teachers for the realities of the classroom. We would further extend it to say that the traditional educational programmes at all levels (school, colleges, universities) fail to interest and motivate female learners to pursue work and careers requiring sound mathematics and science knowledge. Research also supports that "gender differences do not appear at the elementary level in science. In middle school, girls hold more negative attitudes about science than do boys, and have fewer science experiences than boys" (Blosser, 1990: 1) This, as a volume of research also suggests, is for a number of reasons: forces of socialization; stereotypical belief "science is not for girls; inadequate career counseling for career possibilities in advanced science; inadequate exposure to women role models with successful science careers; and influence of home and parents. Schwartz & Hanson, (1992: 1) "At home, parents may unconsciously fail to provide support for their daughters' interest in mathematics [*science added by the authors*], either by

directing their interest elsewhere or by giving all their support for education to their sons." This is true about Pakistan context as well (Farah and Bacchus, 1999). This means that female teachers are inadequately prepared to teach effectively in this technology and information age where technology and critical information processing is becoming an increasingly important factor in the nation's economy. Thus, it is crucial that teachers are provided with the opportunities to enhance their knowledge base through appropriate in-service initiatives/programmes that encourage them to built confidence and competence to deliver quality education.

Since its independence in 1947 Pakistan Government has attempted to improve the quality of education through teacher development programmes but with little success. Hence, the government has allowed not-for-profit organizations and private sectors to take lead role in pursuit of improving quality of education. The Aga Khan University Institute for Educational Development, established in 1993, is one such organization. The institute in collaboration with the government and other interested stakeholders has taken initiatives to enhance the quality of education through innovative in-service teacher programmes that employ 'constructivist' philosophy and 'reflective practice' strategies for teacher development. The programmes focus on experiential learning where all participants (male and female) are encouraged to participate equally and contribute in a conducive and supportive environment. These programmes also emphasize teachers' contextual field-based experiences in classroom settings. I, in my capacity, as teacher educator and faculty at AKU-IED has evidenced the constraints and struggles of the teachers (especially female) striving for improvement and revealing significant and visible changes and had often asked: What can be done to help these teachers to develop the motivation, knowledge, skills, and attitudes for promoting science education locally; in accordance with the social and economical needs of the Pakistan context within a global perspective. I also realized that the more collaboratively I worked with the teachers, the more understanding occurred between me and the teachers. Being a female and having had a similar socio-cultural history as those of the female participants, I came to appreciate their efforts and aspirations to become better teachers. This prompted me to undertake a collaborative and participatory action research project for my doctoral studies to gain a more in-depth understanding of science teacher development in general with sensitivity to female teacher contextual needs.

Collaborative Action-Research a possibility

The research question, as mentioned earlier "How can science teachers' pedagogical content knowledge be enhanced" had emerged from my constructivist approach practice to teacher development. Constructivism, a contemporary theory of learning advocates that knowledge may be individually (Von Glaserfeld, 1995) or socially constructed (Vygotsky, 1978). Knowing may also be seen to co-emerge through human interactions with others and the environment. Thus knowledge may exist only when it is enacted in the interaction (Varela et al., 1991). It, thus, seemed logical to provide the teachers with sites for interactions and critical reflection on experiences and shared meanings through group discussions, conversations and interactions with 'others' to collectively construct a contextual perspective. This research methodology aligns with the Action research encourages change through collaborative action, with equal participation and involvement of all participants. This allows to empower teachers to develop their own personal perspective of good classroom practice by reflecting on their personal and collective experience to strive for shared meanings and understanding. Action research, was thus perceived to have the potential to expand and enhance teachers' knowledge base and, furthermore, result in individuals' personal growth through participatory collaboration. Acton research with its participatory tenet is commonly referred to as 'participatory action research', especially by the feminist researchers.

Participatory action research appeals to the feminist researchers because of its traditions that are committed to emancipation of marginalized and oppressed groups. This it does by honoring, valuing, respecting and bringing forth the lived experiences and personal/practical knowledge of those being researched. Furthermore, 'participatory action researchers' develop and use methods and models of their research practice that "minimize hierarchical relationships between researcher and researched, and that involve a genuinely collaborative approach throughout all stages of the research process" (Reason, 1994). For academic researchers it then, means that they are not the only ones that possess truth and knowledge but their research concerns and "questions [may] derive not from prior research or theoretical considerations, but from the 'work-a-day' worlds of people who themselves are seeking creative solutions to the challenges they face" (Grant 1999:9). The overall intent of participatory action research requires researchers to work with, and not for, the participants to help them effect change through a research process, whereby; the participants have "collective" ownership of the research products. However, possibilities of genuinely participatory research claiming full collaboration are unrealistic expectations (Gustafson 2000; Spalter Roth & Hartman 1996). In practice participatory research is problematic and, thus, has some limits. Experienced

feminist researchers (Kely, Burton & Regen 1994; Vanderplaat 1999 just to name some) have highlighted key complex issues that are debatable:

Simplistic interpretation of the concept of empowerment, namely, even though individuals may acquire greater understanding of the individual problems and societal conditions behind them, can it be interpreted as 'empowering' if there is no link to capacity building to bring about a change.

Empowerment is not a concrete 'thing' that can be "granted" by a researcher or easily "taken" by an individual or group members. It is subjected to personal and institutional constraints. It is a process constantly to be negotiated between all concerned; the researcher, researched and 'others' involved throughout the research process

It is questionable to presume that research participants (researched) desire a strongly participator research process. It may not always be practical because of time constraints (e.g working women with multiple domestic responsibilities)

Participatory approaches may not work if the target group or research participants do not share basic beliefs with the researcher/s.

The time frame of a research project (e.g time constraints of a researcher to complete thesis). This may lead to problems of insufficient time to build a trusting relationship, or premature exit that may leave the participants feeling 'let down'.

Undoubtedly, many action researchers (especially in the academic settings) have come to accept that "collaboration is always fraught with difficulties and complete equality is probably impossible to achieve in any partnership" (Somekh 1994: 365). Nevertheless, they advocate that it is enough to be honest and open to recognize and acknowledge the limits of collaboration. They also suggest that using open settings, such as group and semi-structured interviews "people can contribute significantly to the description and analysis of a social issue that is of great importance to them, and this can be empowering", (Montell 1999: 55). Following these guidelines I attempted to foster as equal as possible and in genuine partnership with the participating teachers as a facilitator of the action research group. The research project was to involve a team external (the Institute for Educational Development academia and one of the authors as a researcher) and internals (teachers, heads of schools and students). Though, I (female researcher) and researched (e.g. female science teachers) were 'same' in certain ways [gender, speaking same language (Urdu), and dressing], yet possibilities for differences were foreseen. My experience from the Institute for Educational Development of Action research projects (e.g. Kanu: 1997) had informally guided me about the problematic aspects of action research between

school and university faculty (externals) in that roles and responsibilities can become difficult to define as 'externals' and school members have different forms of knowledge , levels of thinking, and expertise to offer. The major challenge to collaborate, then, was perceived as issues of 'identity' especially in terms of power relationships. Furthermore, reflections on my personal experiences of working with school heads and teachers in Pakistan and readings of scholars (e.g Hardy and Kirkwood 1994; Oja and Smulyan 1989) raised my awareness of taking multiple roles. Besides being a researcher I realized to be a facilitator, a support person, a resource person, a catalyst, an expert and a critic. More importantly though I was a researcher, I still was to a greater extent a facilitator and a teacher as well. Thus it was intended that the university researcher/facilitator engage in critical self-reflection about own role in action research process to narrow the theory practice gap and help practitioners "get to where they want to get" (Kosmidou and Usher 1991).

Action Research Project

The action research project took place in Karachi, Pakistan as a part of my field-based requirement towards doctoral thesis in 2001/02. My strong desire to pursue doctoral studies emerged as a consequency of my learning from the institutes programs, particularly a one year advanced diploma programs (in math/science), that caused a concern for teachers' about their subject knowledge as revealed during their implementation of new innovations. The distinguishing feature of the advanced diploma programs was reflecting on, upon and about practice through 'success' stories shared by teachers, predominately females. This helped the participating teachers to develop significant confidence to 'voice' their contextual needs and realities in a non-threatening environment and to develop personal conceptual understanding about classroom practice:

There was a change in my teaching after attending this programme. I realized that now I can give the students better teacher and better ways of conceptual understanding. It was also noted by me that students were taking a keen interest in the activities.

(Pardhan, 1998)

However, it took time before the participants began to open up and share their narratives, especially the difficult problematic ones. Inspite of the fact that, I, the facilitator (researcher) was a female and 14 out of the 15 CPs in science advance diploma program were females, the participants demonstrated reluctance and anxiety when it came to sharing of experiences and writing reflections. From the

very beginning of the program I, as a facilitator, felt it necessary to encourage, prompt, probe and invite the CPs to feel comfortable to express their ideas and feelings. With the passage of time, the CPs showed interest in writing reflections and 'voicing' their feelings formally or informally. Some of the significant words and phrases that revealed CPs beliefs and reasons for observing 'silence' were: "it is hard…painful…to speak in front of colleagues' especially male… what if I say wrong things"… "Our seniors, teachers…especially professors… and elders are not to be argued with… they are to be respected because they are more experienced and have knowledge" … "our English is not good as yours…have lived abroad, speak well… if we make mistake what will you think of us." This raised an important question for me as the facilitator "Why inspite of reminding the CPs, 'we are all teachers and mostly female teachers; they still felt insecure, intimidated and uneasy.

Embedded in the 'words' and 'phrases' of the CPs was the notion of 'sameness' and 'otherness'. No doubt as mentioned earlier I had 'sameness' (gender, teacher, dress code, ethnicity, Urdu as common language) but the fact that I was educated in the Western traditions and was a 'University faculty' I was perceived as the 'other'. It became apparent that the CPs were underrating themselves by believing that persons speaking English, getting education from the west and being a 'university-faculty and a senior/elder as 'knowledgeable' 'beings' was to be respected and not to be challenged. This I interpreted as a historical legacy of our traditions of cultures and norms of academia and socially as a whole. Nevertheless, the CPs were inspired and enthused to many innovative contemporary ideas in science education and science pedagogy in particular. They even implemented a number of them in class. Their classroom observations while working with children often revealed problems such as: clarity of purpose of the lesson; selection of appropriate activities and tasks for the level, interest and ability of students; class control; resource management; student questions handling; discussions; time management and gaps in content knowledge. As further probing and inquiry suggested the problem was deep routed in the contextual reality that "large number of practicing teachers…are untrained and unqualified with very low level of education" (Kanu 1997:169). This was also reflected in the CPs 'voices; "I am required to teach physical sciences…I never liked physics at school…how can I teach"… "Chemistry was okay but biology I liked because I could relate to myself and surroundings." The course participants became aware of their gaps in subject matter knowledge and appreciated the time and effort it takes to transform the content in a meaningful and effective way to minimize classroom problems and optimize student learning; in Shulman's words; the teachers' pedagogical content knowledge. I also began to appreciate the importance of participants' (irrespective of male or female) confidence and competence in subject matter knowledge to teach effectively. More importantly acknowledging that participants (predominantly

female) needed time, support and space to enhance knowledge base, since, over and above their rather heavy teaching load and other school responsibilities they had domestic responsibilities of caring for young and old and household chores. Besides, as they often shared they had no one at home to help them with science/math academic learning and had limited mobility to go outside home for socio-cultural reasons. Though all (mostly females) participants successfully completed the one year advanced diploma program, I, as a facilitator, did not feel fully satisfied with understanding about the connections between subject matter knowledge and the teachers' pedagogical knowledge. Thus, for my EdD program, I decided to focus on the area of science teacher education, and more specifically explore viable ways of enhancing science teachers' subject matter knowledge, pedagogical knowledge and the intersection of the two. Thus I intended to work along side with the teachers, with hind sight of Pakistani context where mistakes from professional and elders are unacceptable and to admit a gap in knowledge is interpreted as a matter of shame and threat for appraisal or to keep job at a school. This is highly embedded in the cultural and historical norms of Pakistan society.

Research Intents and Actions

The above described framework enabled me to shape, guide and facilitate the intentions for the research project. One of the intentions was to follow action-research cycles (Kammis & McTaggart, 1988:8) namely planning/preparing, acting, observing/evaluating, reflecting and replanning and so on. This was to incorporate feedback into the subsequent cycle, through reflective practice with intent to improve it. To facilitate this, I worked alongside to advise, guide, choose, design, and prepare tasks and strategies for science classroom. I followed the teachers (either as a participant observer or a co-teacher) into the classrooms and played the role of a critical friend not to evaluate them but to support their development. To further pursue reflective practice, I, scheduled: pre-post conferences, conversations and discussions on a one-to-one interaction basis with each teacher, narratives, discussions, and tutorial sessions (as needed) as a group with all three teachers at appropriate and convenient times. With the teachers' permission, conversations were audio recorded and a select number of lessons video recorded. During the group sessions transcripts of the audio taped sessions were used to explore ways to portray the way teachers think, make meanings, and reflect upon their development. Audio recordings were transcribed and shared on regular basis with the participants for comments, accuracy and member check/ validation. Thus ample opportunities were provided for self and joint reflections to review science classroom practice and make modifications, adjustments, and changes as and where needed. In built in the actions for the first key intention is the second intention to provide the

teacher with as much ownership of the project as possible. Thus, over and above the project expectations the teachers were to be allowed to specify areas and issues they wanted to address as the project evolved. The teachers' ideas and contribution were to be respected, encouraged and used (as much as possible) to shape and direct the project intends and actions to enhance teachers subject matter knowledge, pedagogical knowledge and more importantly pedagogical content knowledge. This was to be done with sensitivity to teachers' needs, concerns and contextual realities.

Community of Learning through action research

Prior to and during the field work of the project active planning and preparation combined with consolidated communicating efforts with the concerned teachers and their heads were practiced. The action research cycles were used under the following themes: Entering the Field with School Heads' Collaboration; Collaborating with the Teachers; and Critical Reflection and Developing Relationship.

Entering the field: Though because of my advanced diploma experiences I knew the schools and the invited teachers I still needed to follow the proper channels to gain entry. Moreover, some heads had changed and some of the invited teachers were in new positions like head teachers or department heads or subject coordinators. My personal visits to schools, interactions with the heads followed by invited teachers, sharing of project overview (written with consent forms), and making spaces and time for clarifications and discussions made the entry smooth and encouraging. The heads interest and willingness is reflected in their words "these teachers need such experiences…it is wonderful you decided to come personally to school…this is the first step to collaboration…I like the idea of invitation." The invited teachers were no longer 'silent beings' but had many pertinent questions, "of course we are asking these questions so we should be aware of things before participating…because once we join we would not like to leave." Their major concern was time commitment. "Time is the main problem…teaching … then other responsibilities … you know life is so difficult after marriage" (group session April 21, 2000). The concern had both personal and cultural dimension. What surprised me was the confidence and openness that these teachers displayed. They no longer were 'silent listeners' but decision makers and even solution givers "if you can manage the research during school timings and Saturdays…we are very pleased to do this research" (group session April 21, 2000). This teacher change I attributed to the teachers advance diploma experiences and subsequently taking up responsible/leadership roles. I also became more convinced that providing enabling environment and

opportunities to teachers to come together and learn together can bring about a change. However, though these teachers had made significant improvement in their teaching career, they still perceived coming aboard the project as an opportunity for further growth through continued interactive, reflective and supportive environment:

…this year I am given to teach a Cambridge class instead of matric. It is more content-oriented and very challenging. … I have just started … learning … Matric (biology) I can tell you even without having to go and look for syllabus. But Cambridge is new … I have yet to know a whole lot. Working with Charan (researcher) …will be interesting and timely because her critical appraisal will further enhance my development as a science teacher … my science teaching especially for Cambridge classes. I am looking forward to … working and learning together. (Nina's Journal Entry Sept. 8, 2000)

Saira, "I want to improve my personal growth and know how I can reflect myself. It will affect my teaching … become more effective … how can we observe our students and then how can we reflect on teaching." Nina and PT (pseudonyms of the other two partners) who were listening attentively … "yes" … "I want to learn English …" (group session, September 15, 2000).

The above anecdotes testify an already trusted relationship between invited teachers and myself but at a student teacher and facilitator level. Now that the teachers had joined the project as members they were to be respected as research partners. I realized the need to be sensitive to the diversity involved and pay attention to partners individual concerns and aspirations over and above my project expectations in a collaborative manner. To explore partners initial (at the start of the project) practice to articulate emerging questions and concerns I played the role of a classroom observer in a non-evaluative but supportive manner. This was mutually agreed upon to stimulate post lesson reflections, share ideas and thoughts. This was consistent with the participants' expectations and was a logical move towards identifying problematic areas and working together as a community with a common purpose.

Collaborating with Teachers

The initial classroom observations of the partners and formal/informal reflective dialogues enabled each member to identify area needing attention. PT_1's concern was 'How to maintain student interest in reading and active student participation in the lesson without rushing it'. PT_2 desired to enhance her personal conceptual understanding of biological concepts and conceptual links with other disciplines namely physics, chemistry and mathematics. PT_3's need was how to engage primary two students in learning in large class setting and manage it, 'the problem of large classroom strength of students…nobody can solve…so it is better to compromise with it' (PT_3's journal entry Sept. 21, 2000).

Thus, members' need-based focus areas as differed. Consequently, the nature and extent of my way of working with each member varied. However, I had to consciously attempt as much as possible to let the partners take decisions affecting their teaching. This was along the guide lines of the following quote cited in Parkay (1996:50):

> Teaching ultimately requires judgment, improvisation, and conversation about means and ends. Human qualities, expert knowledge and skill, and professional commitment together compose excellence in this craft. (-National Board for professional Teaching Standards (United States))

Each partner's need was approached individually. For testing PT_3's hypothesis (above) about managing students learning in large class size I negotiated with her the roles of co planner, co teacher and a critical friend; with PT_2 primarily co thinker, participant observer and critical friend; and with PT, co planner, co teacher on invitation, participant observer and critical friend. During this stage I worked closely and alongside with partners playing multiple roles and following the systematic action research cycles individually, jointly (partner-researcher) and collectively (group sessions). The below anecdotes signify our successes:

We (Researcher and PT_3) had done our planning and teaching and we have changed and added many new activities … Some activities which were really challenging we gave it to the children and you (meant for the group) know … children were really involved in thinking to a level that … there was … optimum (acceptable) level of noise as whatever children were discussing was according to the task given to them. Children didn't quarrel … I was really amazed and

impressed … after this activity I realized that 'activity should have challenge' and we should not underestimate children. (PT_3 group session December 01, 2000)

I felt some inner happiness because students gave good responses and followed the social skills very well … Teacher talked less and students talked more. In this way in the end I didn't feel tired … I achieved my effort that I make interest n reading materials … students took interest in reading and showed enthusiasm in activities (journal entry PT_2 November 8, 2000) … Clear instructions very beneficial for teacher in this way she talks less and gives more time to students to talk and more time to their understanding (Journal entry PT_2 December 6, 2000) … Activity should be tried out before doing in class (Journal Entry PT_2 January 24, 2001)

Our five months (September 2000 – January 2001) of collaborative efforts lead to a trusting and open relationship amongst project group members. A 'community of learners' relationship emerged:

PT_3: Now we are colleagues and partners.

PT_1: we discuss everything … if we had problems we were a bit hesitant there (SST…meaning advanced diploma program) but … here [project] we discuss every thing openly and share everything … Now it is totally different and see we came to you and shared all problems that we cannot do this or that naturally we are learning.

PT_3: And we discuss freely there is no hesitation.

PT_1: You are doing your own work … studying and learning and we are also going through the same cycle. We are not going to get a degree but definitely we are learning.

PT_2: … about SST in the start we had hesitation and … now we discuss freely … Yes, indeed we have come closed and … it feels good. (group session transcript January 12, 2001)

Action Research by Teacher is possible

I found that teachers can engage and do action research through 'systematic observation' and reflection thereafter; through conscious effort and deliberations that provide them with an opportunity and support to do so. The three research partners inspite of their heavy teaching load and other school and familial responsibilities participated in the research with willingness, interest and commitment.

Participants preferred to continue with project activities (classroom visits, group sessions) regardless of unexpected interruptions at short notice that called for new adjustments. Participants themselves suggested the use of telephone to communicate effectively and practically. This is unconventional in Pakistan's cultural practice, "teachers only communicate at school … do not do this (communicating by phone)… in fact talking … mainly social ... is done mainly when people meet at gatherings … like weddings" (phone conversation with participant April 4, 2001). Thus the participants were willing to make sacrifices to be able to achieve their goals.

Participants demonstrated strong sense of commitment and devotion. They made time and space for thought provoking, time-consuming exercises such as writing personal stories about teaching as a vocation, making grids over and above journal writing. They sacrificed their evenings and weekends, made special arrangements and extra time for resources 'today I have Saturday off which I am spending at my sister's house to use her cassette player to listen to my audio recorded lesson' (Journal Entry PT_1 October 14, 2000) … 'After listening to the tape at home, I felt I did not miss anything of the group session of December 1, 2000 … I had got all the handouts of the cycles … but when I listened to the tape these handouts became more clear to me' (Journal Entry PT_2 December 6, 2000) … 'viewing of the video at home was very helpful for writing my reflection and getting a total picture of what was happening in the classroom … (Journal Entry PT_2 October 6, 2000) … 'Today before group session I was listening to the audio tape … the students used to be silent while listening but make a noise when they are asked a one word answer question … questions need to be framed in such a way that it makes students think and not to give the answer in chorus' (Journal Entry PT_3 November 10, 2000). PT_3 made extra time before group sessions to listen to her audio recorded lessons as she was required by her familial responsibilities to be home soon after school. Despite the fact that I was taking much of the partners' free time (non contact hours) since no extra time was provided by the project, they (partners) demonstrated willingness to spend more time to benefit from the project as the above discussion suggests.

Collaborative Teacher Development Possibilities

As the above interactions, descriptions and discussions suggest all three participants experienced significant personal, professional and social growth. This I attribute to the collaborative effort as opposed to individualistic culture of teachers that predominantly prevails in most schools. This is reflected even in participants 'voices' "At schools most teacher are busy with their own teaching and preparation" … "I liked this sharing session" … " I do miss discussing with other persons, being in the project I can now discuss … it helps understanding a lot" … "sharing always helps in lessening the pain." Implicit in this is the participants expressing their need for a community.

For teacher development I support a model of 'community of learners' where teachers work together in a collaborative and collegial manner. I do realize that all teachers may not perceive a culture of working in isolation as a hindrance to their personal growth. Some teachers may conceive it as an opportunity for having privacy and autonomy because collaboration and collegiality they may perceive as interfering with their functional autonomy (Cochran-Smith and Lytle, 1992). PT_3's co-teacher was suddenly observed to be absent from class after a couple of co-taught lessons. This PT_3 explained was because the co-teacher had other things (corrections of students' copies and making reports) to do. She further added that perhaps if she were in her (co-teachers) place she would have done the same. This I content is the remains of the legacy of the colonial heritage of Pakistan's top-down and bureaucratic educational system. The government has direct control of schooling that constraint the teachers' autonomy and empowerment. This leaves little or no space for classroom-based innovations. This in turn impedes teachers' participation and efforts to provide quality education.

Teachers (including females) need to be perceived as autonomous and intellectual beings capable of making decisions about themselves and their classroom practice. Thus, teacher education institutes need to take up a humanistic approach to teacher education. The Aga Khan University Institute for Educational Development is one that works on this principle. It encourages schools, teachers, and tertiary institutions to engage in collaborative action research for school-based problem solving and reform. The institutes' vision is to bring about an educational change over a period of time. My action research project is and example of this with a salient feature of strategically planned activities that were implemented and then subjected to observation, reflection/evaluation and change. In this process the participants were integrally involved in all the activities to the action under consideration to affect change.

(Gurney 1990: cited in Palmier:, p.3) has articulated this as, "action research is a quality means of encouraging change … one that shows respect for practitioners' control of their own practice and learners' control of their own learning." This is what I belief has lead to the success of my project.

The project participants' beginning practice was predominantly transmission approach to teaching. An approach that, as the participants descriptions reveal, is perpetuated by their school culture and educational system at large. Change in participants' practice happened through their experiential learning during in-service teacher development programs at the Aga Khan University Institute for Educational Development, Karachi, Pakistan. That the program greatly influenced their taken-for-granted practice was acknowledged by all three participants. Participants' descriptions and implementation of innovative new ideas indicate their perception of teaching as: an individual activity where teacher has the autonomy of decision making about pedagogy and curriculum; and a dynamic process that requires active inquiry into their practice. Though there was a change in the participants practice, at the initial stage of the project, they still viewed teaching and teacher growth as individual activities rather than a social one.

From my personal experiences and reflections and participants' descriptions of the in-service programs at AKU-IED I had come to realize that the social, cultural, and institutional imperatives that may constrain the implementation of their learnings were inadequately addressed. The participants were, thus, to struggle not only with their pedagogical content knowledge but, also to change the structures and beliefs in the school and society that were barriers to their efforts. The nature and extend of their struggle differed in accordance with the school working environment, since "the contexts in which teachers work are believed to affect what they can do" (Wilson & Berne, 1999, p. 175). PT_1 had less administrative and peer support compared to PT_2. PT_2's school demonstrated a stronger sense of community that supported her development compared to PT_1 who was often grappling with her problems in isolation. However, getting actively involved in the process of action research, the participants became an integral part of a community of 'fellow researchers and learners'. The participants could, thus, "struggle along with others to construct meaningful local knowledge and where inquiry is regarded as part of the larger efforts to transform teaching learning and schooling" (Cochran-Smith & Lytle, 1999, p. 278) in a conducive and encouraging environment.

I argue for promoting communities of science teachers and networking as viable approaches to science teacher development. I believe this can make space for

teachers to avail opportunities for agency, reflection, collaboration, and membership in the community that are critical for change in their practice and eventually reform. I am cognisent that to establish a sense of community needs time and effort, but once it has happened members with different pedagogical content knowledge and curriculum development expertise are likely to interact in increasingly differentiated ways to construct/reconstruct their pedagogical content knowledge socially. This will enable the members to develop shared language and perspectives about pedagogical content knowledge. This I consider as the essence of a learning community.

Teacher development through 'learning community' model is a power pathway to promote a collaborative culture amongst teachers to counter a culture of classroom isolation to strive and improve the quality of teaching and learning, in general, and of science, in particular. This I advocate on the premise that members engage in rigorous discussion and evaluation in non-evaluative, but supportive environment with inbuilt flexibility, tactfulness, thoughtfulness over a period of time. This is a tenet of action research. For my project to form a community of learners through collaborative action research, the school heads' support was instrumental. This is also supported by Dean's (2000) study where she documents support for action research by the administrators. The Institute for Educational Development has encouraged and supported action research, in different parts of Pakistan, with schools and in-service teachers (Dean, 2000; Kanu, 1997). Thus foundation is laid and possibilities exist to promote and sustain communities of learners among science teachers as well. Through a process of dialoguing and negotiating with the school administrators the desired times, conditions, mental space and support for the science teachers can be sought to enable the teachers to work in communities to enhance their pedagogical content knowledge.

It is not always necessary that a university researcher like myself be involved in the action research project. However, should university-researchers be involved, I suggest they engage in second-order inquiry to reflect on their own roles and responsibilities as facilitators/researchers and they assess the action research process's effectiveness. Either way action research can facilitate teachers' personal and professional growth and inspire them to voice their feelings and thoughts. Action research is an important avenue for teachers to improve their teaching and curriculum. I concur with Noffke's (1997) belief that what teachers learn through the action research process can be shared with others. Learning communities to me are appropriate sites/contexts for teacher sharing and learning. This can help to sustain teacher learning through teachers teaching other teachers by encouraging and supporting their intellectual and pedagogical growth. However, lack of time, resources, and differences between

teacher/practitioner research and academic research can act as limitations to the use of action research as a way of sustained teacher learning. I contend that if action research is collaboratively conducted amongst teachers to foster learning communities, committed and willing teachers and willing teachers will strive to sustain on-going learning.

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