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Implementing Education Quality in Low Income Countries

COMPARATIVE PERSPECTIVES IN CREATING GENDER AWARENESS:

Stories from Elementary Mathematics Classrooms in Pakistan

EdQual Working Paper

Gender No.2

By

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September 2009

University of BRISTOL

EdQual

A Research Programme Consortium on
Implementing Education Quality in Low Income Countries

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This paper was first presented at the 10th UKFIET International Conference, University of Oxford, 15-17 September 2009.

This Paper has been published by EdQual RPC and funded by the UK Department for International Development, although the views expressed are those of the Author[s].

ISBN: 978-1-906675-24-0

Abstract

This paper focuses on gender awareness issues as a dimension of addressing the wider issue of education quality in Pakistan from the perspective of social justice. It is based on an action research project that is trying to raise gender awareness among mathematics teachers in Pakistan as an important element of introducing pedagogy of problem solving. In classrooms in Pakistan, boys and girls learn separately and, therefore, teachers and others tend to think that there are no gender issues once access is achieved and the learners are in the classroom. A first step is to enable teachers to become aware of the subtle and deeply rooted assumptions and biases which are reflected in the classrooms, so that, a single sex classroom could be gender biased depending on the teachers' perception of boys and girls as learners of mathematics, and on the assumptions built into the curriculum.

The paper posits that improvement in quality of the curriculum and instruction is integrally linked with issues of access and questions of equity, in this case gender equity. Employing Fraser's (1997) framework of redistribution, recognition and participation, the paper identifies several questions for social justice in mathematics education and makes recommendations for policy and practice.

Key words: gender awareness, social justice, education quality, problem solving

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Introduction

The discourse of education reform globally, and more particularly in low income countries, has broadened to consider access to education in conjunction with education quality. For example, the global initiative on Education for All (EFA)[1] which is primarily about providing access to education for all children, has one of its six goals as "Improving all aspects of the quality of education and ensuring excellence of all so that recognized and measurable learning outcomes are achieved by all, especially in literacy, numeracy and essential life skills" (UNESCO 2000). However, education quality is an elusive and complex notion rooted in the reality of context in which education takes place, so that defining quality could be deterministic and contrary to the purpose. While initiatives to improve the quality of education in schools have focused on various dimensions of schooling, successful school improvement works have shown an explicit, deliberate and unwavering focus on improving curricular processes in the classroom for improved student outcomes (Fullan, 2005; Hopkins, 2003; Anderson 2002). Increasingly, the focus of curriculum reform, including the classroom processes, is towards learner-centered methods that provide space for learners to engage actively in problem solving and critical thinking. There is a global shift from the earlier emphasis on content-heavy curriculum, bounded by disciplines or subjects. As Chilsom (2005) points out, with reference to National Curriculum Reform in South Africa, curriculum reform initiatives are often borrowed and transferred from Northern contexts and are then adapted to the national or local contexts (p.80-81).

This appears to be the case in improving the quality of curriculum in mathematics classrooms. For example, the well known reform in mathematics education led by the national council of education in mathematics in the USA emphasized a focus on problem solving and suggests that concepts and skills should be learnt in the context of problem solving, which should be seen as a thread running through the entire curriculum (NCTM Standards, 2000). Similarly, several programmes of reform in mathematics education in the UK have placed problem solving as a central focus of mathematics teaching and learning (Cockroft report, 1982, Primary Framework for Mathematics UK). Likewise, in Pakistan, teachers in schools collaborating with Aga Khan University have introduced child-centered and activity-based teaching methods to promote critical thinking and problem solving. This is a move beyond the traditional emphasis on rote learning (Khamis & Sammons, 2004, 2007; Halai, 2004). Along the same lines, the new National Curriculum in Pakistan emphasizes logical thinking, problem solving and reasoning in mathematics as an important element of improved quality (MoE, 2006). Similarly, the Sarva Shiksha Abhiyan - the flagship programme of the Government of India to achieve Universal Elementary Education - aims to provide access to all children, particularly girls, to quality of education based on a relevant, life skills curriculum incorporating problem solving skills (Govinda, 2002).

In this project, improvement in the quality of the mathematics curriculum was undertaken through the introduction of an intellectually stimulating problem solving pedagogy which provided equitable participation to boys and girls. Frameworks for problem solving such as those by Polya (1957) and Mason & Burton (1993) were used. These are broad and flexible frameworks which emphasise student engagement in the process of decision making as they start, make progress with and ultimately resolve a mathematical problem. Problem solving processes in the classroom are well documented for providing intellectual and social space for learners to engage with mathematics which is meaningful to them. For example, building on the seminal work of Belenky et al (1986) it is proposed by Becker (1995) that a focus on the process of mathematical thinking in the classrooms promotes "connected knowing". This kind of knowing builds on the personal experience of the

[1] Education for All (EFA) is an international commitment first launched in Jomtien, Thailand in 1990 to bring the benefits of education to "every citizen in every society." Partners comprised a broad coalition of national governments, civil society groups, and development agencies such as UNESCO and the World Bank. EFA has six major goals (for details see http://www.unesco.org/education/efa/ed_for_all/)

learner, and explores what actions and thoughts lead to the perception that something is known. Hence, in teaching for connected knowing of mathematics, one would share the process of solving the problems with the students, not just the finished product or the proof. Students need to see the failed attempts to understand that mathematicians do not arrive at solutions in one go. In teaching for connected knowing, groups are created in which members can nurture each other's thoughts to maturity. Diversity of approaches is welcomed and knowledge is constructed through consensus (Becker, 1995, pp. 169-170). Earlier research from mainly the North American context provides evidence that connected knowing with emphasis on process and cooperative learning, as opposed to completion, is preferred by females and girls (Fennema & Leder, 1990).

Besides engaging students in problem solving, critical thinking and other active learning approaches, it is recognized that improving the quality of classroom processes must incorporate the principles of equity and social justice. In mathematics education, issues related to social justice in the classrooms are discussed from a variety of perspectives. These include a cross-cultural and ethnomathematical perspective which questions the status of mathematics as a universal discipline and challenges "Eurocentrism" in mathematics education (D'Ambrosio, 1985; Powell & Frankenstein, 1997); from the position of "equity" and "equal opportunity" for marginalized communities such as ethnic minorities and immigrant populations (Atweh, 2007); from the perspective of learners' participation in multi-lingual mathematics classrooms where the language of instruction is not the first, often not even the second language of the learners (Setati, 2005); and gender issues in mathematics including the historical gender disparity in access, quality and participation of women and girls in mathematics (Burton, 2003; Fennema, 1978).

In the context of this project, gender awareness issues, as an element of social justice, were studied at the micro level in the classroom where teachers, as active participants in classroom reform, worked towards enabling the participation of boys and girls as learners of mathematics. The framework proposed by Fraser (1997) was found useful in trying to make sense of the gender awareness issues in mathematics education as discussed in this paper. This framework considers three key dimensions of social justice in education i.e. redistribution, recognition and participation. It is often employed at the macro levels where the dynamics of reform are focused on redistributing the benefits of education through improved access across class and the economic divide. For example, Tikly & Dachi (2008) interpret Fraser's three dimensions for application to education in Africa. This interpretation elaborates and exemplifies the theoretical constructs of redistribution, recognition and representation/participation when applied to education at national or regional levels. They have focused on initiatives at the regional level, and recognize the need to deepen and extend analysis through a focus on the national level and local levels where social justice issues are experienced firsthand.

Fraser's framework of social justice can also be employed at micro levels such as in classrooms, where the teacher's concern with social justice ensures that all students have access to knowledge and cultural capital to be able to learn effectively and compete within the school and beyond. Likewise, recognition at the classroom levels entails the teacher acknowledging and acting upon the diverse backgrounds and needs of various individuals and groups such as gender, or ethnic minorities. Participation requires the teacher to create space in the classroom processes for the voice of the marginalized to be heard and their optimal participation ensured (Ellis & Hill, 2009). Here, cultural capital is used as in Bourdieu's theory to include forms of mathematics knowledge, skills and attributes that could potentially give the learners an advantage to succeed in mathematics (Grenfall & James, 1998, pp. 24-25). For the purpose of this paper, gender awareness is similar to Fraser's notion of social justice and entails teachers identifying gender issues related to how boys and girls learn mathematics and their role as teachers in addressing those issues to enable equitable participation for both.

This paper reports from an action research project undertaken as part of the EdQual Research Programme Consortium[2]. The project was implemented in three countries of South Africa, Rwanda and Pakistan. The aims of this research project were guided by the goal of the consortium i.e. to investigate education quality. This investigation studied the process of implementation of the national curriculum reform in the three countries respectively, in the course of which, approaches to problem solving and improving gender equity in mathematics classrooms were developed. The focus of this paper is on the findings from Pakistan, where emphasis on gender equity as an element of social justice was more pronounced because of issues which are discussed at length in this paper. Having said that, it is recognized that teachers were simultaneously working on problem solving which provided a comparative background to the emphasis on gender awareness issues.

What follows is a brief overview of issues related to gender and mathematics education. It draws from a wide range of resources from mathematics education, generally and with specific reference to Pakistan. This overview is followed up with a more specific introduction to the context and process of research. In particular, those contextual details and process decisions are provided which had a bearing on gender awareness issues. Findings are presented in the form of stories which narrate key findings about teachers' sense of self efficacy in mathematics, problem solving in the classrooms and teachers' awareness of gender issues in mathematics education. The paper concludes with a discussion on conclusions drawn with implications and recommendations for policy and practice in reform in mathematics education.

Gender and Mathematics Education

The relationship between gender and performance in mathematics has received considerable attention in education. In particular, the last few decades have seen an increase in research on issues related to boys' and girls' access, performance and achievement, and participation in mathematics (Gallaher & Kaufmann, 2005). An overview of the history of modern schooling shows that culturally and traditionally, gender roles and expectations have defined males as bread earners and providers, and females as care givers to the family at home; in line with these traditional roles and expectations, access to schooling and education has been in favour of boys. While most industrially developed nations in the north and west have bridged the disparity in schooling participation rates, many countries including South Asia continue to have significant gaps, with the proportion of girls not attending schools being much higher than that of boys (Jha & Kelleher, 2006). Of course, the initial disadvantage in participation in schooling has implications for subsequent gender equity in participation in mathematics education. To address this disparity in access to mathematics education of boys and girls, initiatives are taken internationally. These include, for example, the global initiatives on EFA and Millennium Development Goals[3]. Indices and measures are developed by UNESCO to document and measure the progress made in terms of gender parity in access and achievement in education. These indices show that there has been considerable progress in providing equitable access to education for boys and girls. For example, according to the gender parity index[4], access to and participation at primary school level has greatly increased in the South and West Asia region, and by 2003-04 the total enrolment rose by

[2] Implementing Curriculum Change (science & mathematics) for Reducing Poverty and Improving Gender Equity. *EdQual* Research Programme Consortium (Jan 06-Aug.10). Bristol University UK. Funded by DFID http://www.edqual.org/

[3] At the Millennium Summit in September 2000 the largest gathering of world leaders in history adopted the UN Millennium Declaration, committing their nations to a new global partnership to reduce extreme poverty and setting out a series of time-bound targets, with a deadline of 2015, that have become known as the Millennium Development Goals (MDGs). These are the world's time-bound and quantified targets for addressing extreme poverty in its many dimensions (http://www.unmillenniumproject.org).

4 The Gender Parity Index (GPI) measures progress towards gender parity in education participation and/or learning opportunities available for women in relation to those available to men. It also reflects the level of women's empowerment in society.

19%. But a fifth of children of official primary school age remain out of school. Two-thirds of out-of-school children are girls (21 million) and the region has the greatest gender disparities in primary education. Very large disparities are found in Pakistan with a female/male enrolment ratio of 0.74 (UNESCO, 2003-04).

Besides access to basic schooling (and therefore to mathematics), girls' under performance and underachievement in mathematics has been a source of much concern the world over, with a widespread belief that males outperform girls in mathematics. Research has focused on issues related to girls' enrolment and performance in advanced mathematics courses and especially on high stakes tests such as the standardized Scholastic Aptitude Tests, popularly known as SATs, used for college admissions in the USA (Chipman, 2005). In general, in the technologically advanced countries in North America and Europe, sex differences in mathematics achievement prior to secondary school are negligible. By the end of secondary school, however, sex differences in mathematics test performance that favour males have usually been reported (ibid). Various explanations, including those routed in bias in test items and/or differences in course taking, have been proposed for these historical differences (Ma, 2008; Fennema, 1978). However, internationally, since the 1980's trends in student achievement in United States, UK and other technologically developed countries in Europe show that girls are either closing the gap in mathematics achievement or doing better than boys. This trend is also evident in reports from the results of large international studies on student achievement in mathematics and science such as TIMMS [5] 2003 and PISA, 2005 (Ma, 2008). The trends in girls' improved achievement in mathematics in technologically advanced countries suggest that the benefits of education have been distributed more or less equitably across gender, but it does raise the question about the emerging negative achievement gap for boys. Moreover, distribution has to be seen in conjunction with the other two dimensions i.e. social justice of recognition and participation, because the improved access to mathematics and achievement in mathematics has not necessarily translated into participation of women in advanced studies in mathematics and in professions related to science and mathematics (EDQUAL, 2007).

Gender issues in mathematics education in Pakistan, which is a highly gender segregated society, are pronounced and manifest somewhat differently even when compared to other low income countries such as those in sub Saharan Africa and South Asia (Barewell et al, 2007). Pakistan takes explicit account of gender in providing access to and administration of schooling. It divides schools mainly into those with male students with male teachers, and female students with female teachers. Typically, secondary schools in Pakistan are single sex schools and parents also prefer to send their girls to a single sex school. In the case where some private schools offer co-education at secondary levels, boys and girls usually sit in separate sections of the same class. Rural elementary schools are the main source of the gender gap in mathematics achievement because of the inability of rural schools for female students to retain women teachers with adequate training in mathematics, coupled with a higher average level of education for male teachers than for female teachers (Warick & Reimers, 1995). More recent national statistics in education in Pakistan show that there is considerable improvement in bringing gender parity to education. However, according to the details available on the website of the Ministry of Women's Development (2008) of the government of Pakistan, the progress is slow and deep inequities persist.

Pakistan is not a participant in TIMMS or PISA. However, results of the NEAS[6] a large-scale national assessment in mathematics taken at grade four (8-9 yrs) in 2005 and again at grade eight (12-13 yrs) in 2008 show that the mean score of girls is higher than boys at grade four level but is lower

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[5] The OECD Programme for International Student Assessment (PISA) which surveys reading, mathematical and scientific literacy levels and Trends in International Mathematics and Science Study (TIMSS), conducted by the International Association for the Evaluation of Educational Achievement (IEA) which surveys student achievement in mathematics and science.

[6] National Education Assessment System, Ministry of Education, Government of Pakistan. http://www.neas.gov.pk/

than boys at grade eight level (Kamaluddin, 2009). These results confirm what is known from international comparisons that the gender gap in favour of boys increases with schooling and the gender gap in favour of girls is more in the case of technologically developed countries where the societal norms and practices are not highly discriminatory against females.

Curriculum processes and teaching often manifest wider cultural and societal patterns of behaviors and traditional stereotypical gender roles of women and men. For example, research studies from Pakistan (Pardhan, 2009), Uganda (Mirembe & Davies, 2001), and Rwanda (Huggins & Randell, 2007) show that gender stereotyping in mathematics starts early. By third grade girls begin to rate their competence lower than boys, even when their grades are higher or the same and by sixth grade girls see mathematics as less important to their career goals than boys do.

Certain emotive and affective factors with implications for participation in mathematics are also exacerbated in the course of schooling. For example, it is well established that there are no differences in girls' and boys' confidence in the school examination and on problem solving in elementary mathematics classrooms. However, as students progress through high school the difference in confidence becomes wider. In a study of over 1200 high school students in the USA it was established that boys had greater confidence than girls, and as the students progressed through high school the difference in confidence increased, so that by the time they reach middle school boys begin to see mathematics as more useful (Fennema, 1978).

Curriculum is negotiated by the teachers who often perpetuate or reinforce the patterns of gender stereotyping and gender bias. For example, research from a range of contexts, including both developing and developed countries, has shown that teachers of all grade levels tend to call more often on boys than girls, ask them more complex questions, provide them more academic feedback and attribute their success to ability. More teachers believe that girls succeed in mathematics because of their hard work (Mereku, 2004; Pardhan, 2009). There are socially and culturally rooted issues which influence teachers' views about girls and boys as learners of mathematics in the case of Pakistan. For example, (Halai, 2007) reports from a survey of a cohort of in-service teachers comprising 80% women and 20% men. One of the items in the survey asked teachers to respond to the statement "Boys are better mathematicians! Do you agree? Why? Why not?" In response to this item, almost 86% agreed that boys were better mathematicians. Illustrative responses were of the kind given below:

> Yes, boys are better mathematicians because they think in (sic) deeply and try to find better solutions.
>
> To some extent I agree with this. And probably the reason for it is that Allah has made man superior to a woman. It is natural that from childhood they (boys) ask questions why, what, how. And comparatively girls from the beginning you explain to them and they accept it. They have curiosity but from the start that element of curiosity is bounded so that it stops. This is the reason that our experience tells us that boys learn better.
>
> Where boys are concerned I would say that boys are very intelligent but they are also very naughty and do not pay attention. Whereas girls pay attention try to learn. As compared to boys they want to try to do/achieve better. Hence their attention is more towards learning. Whereas boys have their attention on other activities besides learning hence they lag behind girls in the process of learning. (Halai, 2007, p.118).

These responses, and others like it, indicate that teachers' perceptions of boys and girls as learners of mathematics are deeply rooted in the socio-cultural context and experiences of the teachers. Interventions aimed at change in teachers' practice would need to enable teachers to confront and question these deeply held views.

Along the same lines as teachers and teaching, textbooks showed a strong bias in favour of boys. For example, analysis of mathematics textbooks have typically shown that the books favoured the male learner by positive images and reinforced certain dominant gender roles such as women as care givers in domestic settings (Halai, 2007; Mirza, 2004).

In sum, emerging over the last few decades there is recognition of gender disparities at macro levels in girls' access, achievement and participation in mathematics education. However, there is relatively less understanding of the classroom processes for teachers to recognise the diverse needs of boys and girls as learners of mathematics and develop pedagogic practice for them to participate equitably in learning mathematics. This is especially true of classrooms in developing world contexts where much research has focused on numerical indicators related to enrolment and achievement data so that contextually rooted insights into quality of classroom processes, especially with a gender focus, are limited.

Implementing a Problem Solving Curriculum and Promoting Gender Awareness: Context and process of research

Pakistan's Education system can be broadly divided into 'Basic Education' (primary, elementary and secondary levels) and Higher Education (post secondary and graduate levels). Both are governed by separate ministries with distinct management and financial systems. Mainstream or government schools offer primary education from class I – V (5 to 9) and then middle or elementary schooling, class VI-VIII (10-13) and finally secondary schooling, class IX – X (14 – 15). In classes IX and X students take the secondary school matriculation examination which is conducted by the Boards of Secondary Education. Mathematics is taught as a compulsory subject and the curriculum content is organized mainly into five major strands: number concepts and number operations, measurement, geometry, data handling and algebra.

Policy making, including Education Policy and setting the strategic direction, is the responsibility of the federal government[7]. Implementation is mostly carried out by the provincial governments and more recently from provincial to districts level. Curriculum development is the purview of the ministry of education in the federal government and is undertaken through a consultative process with the provincial governments through their respective education departments. The District Government is accountable to the people and the Provincial Government for improvement of governance and delivery of services. Affairs of education at the level of district are looked after by the office of the Executive District Officer Education (EDO-E).

In 2005 – 2006, the Ministry of Education (MoE) undertook several reform initiatives in education in Pakistan. This wave of educational reform led to the development of a new Education Policy along with a curriculum review and new scheme of studies (MoE, 2009). The New National Curriculum 2006 for mathematics is organized in five standards which have been kept broad for flexible interpretations. These standards are: (I) Numbers and Operations, (II) Algebra, (III) Measurements and geometry, (IV) Information handling, (V) Reasoning and logical thinking. This last is a significant new addition, because as the document states it would enable a focus on standards and benchmarks for development of mathematical thinking, including problem solving. In the national curriculum for mathematics, the teachers' role has been rerouted from dispensing information to planning investigative tasks, managing a cooperative learning environment, and supporting students' creativity in developing rational understanding of the concepts of mathematics (MoE 2006, National Curriculum for Mathematics grades I – XII, p. 2-3).

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[7] Pakistan is a federation with four provinces i.e. Punjab, Sindh, Baluchistan and North West Frontier Province (NWFP); federally administered areas, Azad Jammu and Kashmir, and the federal capital Islamabad. Sindh and Baluchistan include some of the most poverty stricken regions in the country.

The action research project reported in this paper was undertaken with an underlying assumption that reform initiatives such as the New National Curriculum are implemented at the grassroots level by the teachers in the classrooms. Hence, to understand issues pertinent to the quality of education, it would be worthwhile to study the process of implementation of the curriculum reform in specific contexts. An action research approach was considered suitable because the systematic process of action and reflection would lead to development actions aimed at improving the social reality. It would bring together development of knowledge and change in the community through the empowerment of teachers and other key decision makers in the school. The action research process is derived mainly from Kemmis, MacTaggart & Retallick (2004) and Berge (1999). Certain key features underpinning the action research process were:

a) ownership of the research process would be an important consideration for all. For this purpose, roles and responsibilities of the university academics and school teachers were discussed and delineated. Action in the field, ongoing analysis on action, theorizing and deliberation on emergent issues would be a shared responsibility of school teachers and university academics. However, data collection, management of data, formal analysis and dissemination would mainly be the responsibility of the university participants;
b) the purpose and process of action research would be empowering in nature. Teacher empowerment through participation in the decision-making process, developing contextually appropriate responses to problem resolution and considering ways of sustaining the reform initiated would be built into the research process;
c) the process would be cyclical and evolutionary, building on the issues and concerns identified by the teachers. The systematic process of action and reflection would lead to development actions aimed at improving the social reality;
d) collaboration within the community and across would be a significant element of the research process so that sustainable networks of action would be developed.

A baseline study, including a literature review and needs analysis was undertaken in key areas, including observation of teaching practice, stakeholders' perceptions of gender issues in mathematics, and textbook analysis from a gender perspective. The needs analysis highlighted two key foci for the implementation of the new curriculum for mathematics learning in classrooms with the aim of improving quality and improved gender parity. One was the focus on cognition involving a shift from a rote–recall orientation of learning to a more thinking and problem solving based orientation. These improvements were largely in academic and cognitive terms, such as emphasis on problem solving and logical reasoning as a specific standard in the new national curriculum 2006 being initiated in Pakistan (MoE, 2006).

The other area of need was a sociological focus on reducing disadvantage in terms of gender inequity in the classroom processes of teaching and learning. The focus on gender equity came from the literature review by the university based researchers, and from their motivation to align the research focus with international reform agendas and gender parity is one of them. As will be discussed later, this had implications for gender awareness issues.

Schools for participation in the research were selected on the basis of a "District Education Index" (DEI). The DEI investigates the dispersion in the educational status of districts irrespective of their economic status, and measures the average shortfall from a perfect score of 100 percent. The closer the value of the DEI to 100, the better endowed it is with respect to education variables. Thatta and Tharparkar were at the bottom quintile amongst all districts in Sindh on the basis of this DEI (SPDC, 2003). It was decided to select schools in District Thatta as it would be possible to make the school visits in a day, thus reducing the visit costs from Karachi the provincial capital of Sind where the university researchers were situated. From the seven talukas (a sub-district unit) of Thatta, Mirpur Sakro was selected as it was among the most poverty ridden talukas in the district. Of the fourteen high (secondary) schools in the taluka Mirpur Khas, four schools were identified through a consultative process with the EDO-E Thatta. However, due to resource constraints, work was undertaken in three schools. Twelve mathematics teachers of classes VI-VIII, participated in the action research project. Of these, eight were women and four were men.

University researchers visited the school at least once a month over the period 1st January 2007-31st August 2009[8]. On days that the university team visited the schools, there were classroom observations as well as pre-observation and post-observation conferences. In the pre-observation conferences, teachers shared their lesson plans incorporating problem solving tasks and processes, discussed possible issues in implementing the plan in the classroom and did mathematics together with the university researcher. In the post-observation, conference lessons were analysed to identify emerging issues and questions were raised to promote reflection on pedagogic practice and gender awareness issues.

School based teacher workshops were an important strategy, where teachers and university researchers worked together to discuss theory related to problem solving and to develop a shared understanding of what it meant to teach an enriched curriculum along with promoting gender equity in learning mathematics in the classroom. For example, a classical and broad framework of problem solving, including the rubric of plan, act and review (Polya, 1957) was shared. Likewise, questions were raised about teachers' expectations from boys and girls as learners of mathematics and related issues. The underlying principle in the research was to see change as development actions rather than a priori intervention. Almost every school visit included one workshop where all mathematics teachers met with the university researchers. Once a term, a taluka workshop was planned for teachers from all participating schools and other mathematics teachers from the taluka to participate. Due to political turmoil in the region, only three of the five taluka workshops could be organised.

Instruments were developed to guide classroom observation, pre-observation and post observation conferences (see appendix A & B for a sample instruments). In researching teachers' views about teaching boys and girls, a teachers' "self –inventory" (appendix B) was developed, which was mainly drawn from Mason (2002). Detailed field notes were maintained of all observations, interviews, conferences and workshops. Data comes from more than 45 school visits with 30 lesson observations, as many pre-observation and post-observation meetings with teachers, teacher workshops, and interviews with head teachers and other education stakeholders. Ongoing analysis was a significant feature of the research process as it progressed over the stages from an initial needs analysis to identification of development activities and interventions. Besides the ongoing analysis, systematic analysis of data was undertaken. The tools employed for gender analysis are noted in appendix C.

Stories from Schools and Classrooms

The forthcoming section provides brief stories illustrating key findings about creating gender awareness in the context of a problem solving curriculum in mathematics. These are mainly to do with the teachers' sense of self efficacy in mathematics, introduction of problem solving in the classrooms, and socio-cultural issues in boys and girls in mathematics learning.

Male and female teachers' sense of self efficacy in mathematics

Initial meeting with the teachers for needs analysis showed a distinct difference in male teachers' perception of their needs as compared to the female teachers. In the Boys' School, the head teacher, who had a masters degree in mathematics, and the mathematics teachers were univocal that they did not see any major needs in terms of their development, teaching, and improving students' performance. The head teacher maintained that he had a very experienced and appropriately qualified staff and his students performed well in the matric examinations. Moreover, the fact that these students were continuing with their education, and had not dropped out,

[8] The field work would end by 31st December 2009

suggests that parents were satisfied with their children's education. Hence, he was satisfied with the performance of his school. It was not possible to do any trend analysis because databases were not maintained of the school examination results. The teachers mainly echoed similar sentiments. They maintained that they were knowledgeable in school mathematics and experienced in teaching. However, they would appreciate if participation in the research could provide them some exposure to innovative teaching methods as they did not have any exposure to it.

In both the Girls' Schools the respective head teachers complained that it was very difficult for them to find teachers who were suitably prepared to teach mathematics at the elementary and/or secondary levels. One head teacher stated that due to this shortage she had started to teach mathematics because she was keenly interested in the subject even though she had not studied it beyond high school. Teachers confirmed that they taught mathematics lessons only because "madam" had asked them to do so, but they did not feel confident in teaching it to elementary and/or secondary classes. Indeed, in the needs analysis session, one teacher picked up the textbook and pointed out several word problems. She said to the author, "Miss we ourselves do not know how to solve these problems involving volumes of cylindrical shapes. How can we teach problem solving to our students?" (field notes). On several occasions during the three year period of field work, the head teachers and the teachers acknowledged and appreciated the opportunity of upgrading their mathematics content knowledge in the course of the workshops and pre-post conferences. Earlier, at the time of entry negotiations, the EDO-E of District Thatta had stated that he would truly welcome any contribution that the project could make towards enabling the "women teachers" in enhancing their mathematics content knowledge as these teachers mostly did not have the qualification to teach mathematics (field notes, introductory meeting with the EDO-E).

In terms of qualification, male and female teachers fulfilled the eligibility criteria for secondary school teachers provided by the Ministry of Education i.e. they should be masters graduates with at least a B.Ed. However, a detailed examination of teachers' academic and professional qualification showed that even if women teachers fulfilled the eligibility criteria they did not have mathematics as their major in the undergraduate or graduate studies. The male teachers had studied mathematics at least up to their first degree. The disparity in teacher quality in the girls' school and the boys' school reflects the general pattern in teacher qualification in Pakistan (Warick & Reimers, 1995; SPDC, 2003; Halai, forthcoming).

Some evidence of the implications of differing qualifications and sense of efficacy in mathematics was found during teachers' engagement with the problem solving mathematics tasks in the course of the workshops. For example, when working through the textbook topic of formula of volume of cuboids, male and female teachers in separate school-based workshops worked through the task: "Take a rectangular sheet of cardboard 20 by 26 cms and from each corner, cut a square. Fold the resulting flaps to form a box. What size corners should be cut in order to maximise the volume of the resulting box?" Not surprisingly, teachers had different approaches in the course of working through the problem. For example, all of them produced boxes with square cutouts, and through observation of boxes they concluded that the higher the height the greater would be the volume. The male teachers picked up the co-variation relationship between volume of the box (v) and the height of the box (h) and ultimately resolved the problem. However, in the Girls' School, the resolution to this problem was not achieved by the teachers and had to be taken through the process with support of the university researchers.

The difference in teacher qualification and their sense of self efficacy in mathematics suggests that the cultural capital in the form of mathematics knowledge is not equally distributed among the male and female teachers. This situation raises social justice issues which are discussed later in this paper.

Problem solving process in the classroom

Baseline reports showed that teaching in the Boys' School was more or less the same as that in the Girls' School. It was characterized by the teacher explaining to the class the mathematics rules and procedures and the students following those rules/procedures and memorizing them for recall. Textbooks prescribed nationally were the only resource material available to the teachers. Initially, teachers across the board maintained that all mathematics teaching and learning could be characterized as "problem solving" because it entailed teachers working through a mathematics problem on the blackboard and then the students emulating the process to find solutions to other problems given in the textbooks. It was through their engagement in the problem solving workshops and subsequent reflections that led to the realization that students' active engagement in the process of problem solving and rationalizing the mathematical decisions they took was a significant feature of the problem solving process.

When it came to introducing the problem solving framework in the classroom, there were prominent differences in approaches that teachers employed to open up spaces for students to engage in the process of problem solving. Male teachers were more confident and in the first year of the project started to plan lessons which incorporated rubrics of problem solving in their teaching. An emerging pattern in their teaching was creation of space for students to explain their reasoning even when a wrong solution was proposed. For example, in a lesson on conversion of number from Base Ten to numbers in Base Two, the students found it difficult to do the conversion. The teacher spent considerable time inviting students to the blackboard to explain their reasoning in the process of conversion of numbers. At one point, he asked the student, who was faltering with the conversion at the blackboard, to deconstruct the number 4224 in terms of its place value of each digit to ascertain that students had the basic understanding of place value understanding in Base Ten. This creation of space for students' perspective and voice was a significant shift from their traditional practice. Additionally, the lessons invariably started with problem solving tasks which were not taken from the textbook. Instead, the tasks set in the textbook were assigned as home work or for practice.

In the case of the female teachers, the university teachers had to co-teach with them to create a scaffold. It was evident that they had gaps in knowledge which necessarily had to be filled to enable them to deal with the possibility of varied approaches to problem resolution being employed by learners. Very often, the post lesson observations would be spent on discussing content knowledge and not necessarily pedagogic issues. However, late in the second year of the action research, teachers in the Girls' Schools also started to plan and teach lessons which incorporated problem solving. For example, in a lesson on factorization, Nuzhat (pseudonym) did not provide one procedure or rule for students to factorise a given algebraic statement, which was a major deviation from her usual practice. Two students approached the factorization as given below:

Student I
$25 + 50$
$= 52 + (52 \times 2)$
$= 52 (1+2)$

Student II
$25 + 50$
$= 52 + (5 \times 10)$
$= (5 \times 5) + (5 \times 10)$
$= 5 (5+10)$

Nuzhat, who was monitoring the class by going around, saw the two different methods and invited both the students to present their work on the blackboard for the rest of the class to see. She then invited the class to discuss both methods and come to the conclusion that a mathematical problem could be resolved through multiple methods. In the course of the lesson she encouraged Student II to see that she could have further factorised 5(5+10). In her post lesson reflection she said that she had recognized that spending time in discussing and understanding the process (of problem solving) was as important as getting the answers.

Gender segregation and social justice

Teachers, the head teacher and the other stakeholders in education considered that providing girls with access to schools and classrooms is the same as providing equitable quality in education to both boys and girls. They maintained that once students had access to the classroom there was no gender disparity because with the "same textbooks and same syllabus" boys and girls had available the same quality of mathematics learning. Issues regarding unequal access, lower expectations from girls, and different opportunities for female teachers were not taken into account by them, even though they were deeply aware of these disparities. For example, during the data collection, it was found that the participating school which was documented as a "Boys School" in the records of the office of EDO-E, had in class IX and class X, eight girls each sitting with the boys. The head teacher informed us that there was no secondary school for girls in the village and the parents wanted the girls to continue with their education, hence, they were accommodated in the boys' school. On inquiring if the district education office and community members were aware that this was the situation, he provided an apologetic explanation that he had requested the district office to upgrade the elementary girls school to the status of secondary school so that the girls did not face this inconvenience. However, the bureaucracy moved very slowly and the application was still pending. The teachers and the head teacher recognized the needs of girls as learners of secondary mathematics. In their interviews and statements in the self inventory, these girls were referred to as "becharis" (poor things). However, "becharis" is a nuanced phrase with layered meanings and one usage of "becharis" is also recognition that the position of girls is weak (in the largely male dominated and gender segregated rural society) and, therefore, their access to education and its outcomes is problematic. To facilitate the girls' participation in schooling some rules were bent to accommodate them. For instance, they were exempt from the school assembly, co-curricular activities or any school event where the students mingle freely. They were allowed to come late and only participate in the academic work. From the teachers' perspective, this accommodation of girls in the Boys' School was not necessarily affirmative action on the part of the community; instead they considered it as a failure on the part of the education providers to take into account girls' need for high schools.

Discussion and Concluding Remarks

Several conclusions can be drawn from the findings and discussion so far. Firstly, teachers' awareness of gender issues as an element of pedagogic practice in the classrooms was through a lens of equality for boys and girls. Secondly, teachers as agents of change played a crucial element in ensuring that centrally driven reform was implemented at the level of the classroom. However, the potential of teacher agency was realized when teachers were participants in the reform process and not just implementers of reform. Thirdly, teachers' engagement and uptake of gender awareness issues was slow as compared to their engagement and uptake with academic enrichment of the curriculum through problem solving. Finally, responses to gender awareness as a social justice issue at the classroom level is linked to social justice at the policy levels for teacher education.

Teachers across the board considered equality in access as synonymous with equity in boys' and girls' learning of mathematics. However, implementing a problem solving curriculum in single sex mathematics classrooms showed that boys and girls entry into mathematics classrooms did not necessarily mean that they would be exposed to the same curricular process with comparable quality of mathematics instruction and opportunities for learning. For example, initial observations showed that the classroom teaching and learning in boys' and girls' classrooms was almost the same. It was largely teacher-led and textbook driven. To this extent, it is a justifiable claim that boys' and girls' access to mathematics classrooms provides them with comparable quality of teaching and learning. However, as teachers began to work through open-ended mathematics tasks suitable for developing problem solving skills, differences began to appear. As noted in the findings section above, male teachers had done more mathematics and were therefore more confident about taking the new approaches to the classroom. However, girls were being taught by women teachers, most of whom had done very little mathematics beyond high school, and also had a very low self concept as mathematicians. While the knowledge gap could be addressed through intensive in-service provision or through better pre-service preparation and selection, these observations raise other issues. For example, Pajares (2005) maintains that self efficacy beliefs are a significant contributor in decisions about whether or not the students would pursue higher education in say mathematics and that "verbal persuasion and vicarious experiences nourished the self efficacy beliefs of girls and women as they set out to meet the challenges to succeed in male dominated academic domains" (p.308). However, girls in middle and secondary school classrooms in Pakistan are more likely to find teachers who have a low sense of self efficacy in mathematics with concomitant implications for their confidence-building and enjoyment of learning mathematics. Additionally, the nationally prescribed textbook, which is often the sole resource that the teacher has recourse to, is seriously biased in favour of boys (Halai, 2007; Mirza, 2004). Hence, the textbook may be providing the "same mathematics content" to the boys and girls, but the messages about mathematics and related professions give positive messages to boys.

The second conclusion is that the teacher's agency was crucial in ensuring that the national reform initiatives did not remain within the confines of documents but was implemented in the classroom. The process of action research and the stories from the school contexts illustrate that the intent of the curriculum change was negotiated by the teachers. Without teachers' engagement in the process of planning, teaching and reflecting on the issues emerging from the continuous action, the changed curriculum could not have been implemented in the classroom. However, the process of reflection in the course of this action research project provided teachers with the space and opportunity to pull back from routine, recognize the importance of creating space for students to take decisions in the course of mathematical problem solving and for them to develop responses to emerging issues.

The third conclusion is that teachers' uptake of the problem solving was greater than their engagement with issues regarding gender awareness. Based on the emerging insights from the field, there could be several explanations for this. One explanation is that the process of curriculum implementation takes place in the schools and classrooms, and, therefore, the context of raising gender awareness was also situated in the schools and classrooms. However, recognition of gender issues is integrally linked to larger societal issues such as perceptions of gender roles and expectations. Teachers appeared to be more concerned with the day-to-day classroom issues such as "coverage of content topics" and often did not see it as their role to engage with those larger issues in the course of their teaching. Another explanation is that gender equity issues are complex and not easy to "observe" in the course of classroom teaching, especially in a single sex classroom. On the other hand, issues of intellectual engagement in problem solving emerge in the course of the classroom processes. For example, when students presented the teachers with a wrong solution of a mathematics problem, teachers recognized it as an issue related to students' knowledge and understanding. However, they could not necessarily see it as a gender issue because they did not have a comparative lens to do so. Yet another explanation for teachers' relatively greater ownership of the problem solving processes was that the National Curriculum 2006 articulated, quite forcefully, the focus on improving the academic content and process. Inclusion of gender awareness as a dimension of education quality came from the university researchers. Hence, teachers felt that emphasis on problem solving was aligned with their needs and were more ready to take it up, with the consequence that patterns of classroom interaction showed a problem solving curriculum being enacted in the classrooms, girls were provided access only to the scholastic activities in boys' schools, and content knowledge enhancement became a key focus of the workshops. This observation signals the need for policy makers such as those of the National Curriculum statements to recognize that improving the quality of the mathematics curriculum is a value laden exercise inextricably linked to the multi-dimensional issues of social justice. A higher premium on cognitive development could lead to a redistribution of space in classroom interactions thereby providing access to learners to mathematical knowledge and skills. However, this access does not necessarily recognize the specific needs of the marginalized, in this case girls, with strong implications for their participation in higher mathematics. Initiatives to improve the education quality would need to create an overt emphasis on the multiple dimensions of social justice in quality.

Finally, emerging from the above a conclusion is that social justice in the classroom is linked with incorporation of a social justice framework at policy levels, in particular, in policies pertaining to nationally driven reform and in teacher development. For example, for effective implementation of a centrally driven reform, it was important that cultural capital such as mathematics knowledge and pedagogic knowledge be distributed across the board so that all teachers, and not some, are proficient in mathematics and adequately prepared for teaching. However, differentiated qualification of teachers based on gender or region implies that teacher preparation and quality is very diverse across the school system. Implementing curriculum reform without due recourse to teacher professional development and taking policy measures to promote equitable provision of teachers could mean that the curriculum reform is weakly implemented in those schools where it is the most needed. Furthermore, participation of teachers could be ensured through inclusion of their voice in decision-making at various stages in the reform process including recognition of their role as participants in the reform process. This, in turn, could lead to an increased sense of teachers' agency in the change process. One approach, which was found useful in this project for raising gender awareness, issues was opportunities for ongoing professional development and reflective practice.

To conclude, for education as a key element of development, several indicators are employed to measure the progress, or not, in achieving the target of development. Typically, these indicators are numerical e.g. access, enrolment rates, dropout rates, percentage of GDP spent on education. However, this study provides strong evidence that numerical focus has to be in tandem with a focus on the process and nature of the education reform initiatives. This situation raises significant issues for the commitment to EFA goals, including improving the quality of curriculum and promoting gender equity.

Acknowledgement: I wish to thank team members Sherwin Rodrigues, Tauseef Akhlaq, Munira Amir Ali, Sahreen Chauhan and Nusrat Rizvi who contributed to the field work at various stages in the project. My sincere thanks also to all the teachers - without their generosity of time and commitment this research would not have been possible.

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Appendix A

POST OBSERVATION INSTRUMENT

This is a reflective instrument whose purpose is to enable the teacher to identify issues of concern that culminated from the lessons and strategies on the best approach to address them for the betterment of the next lesson.

1. In your view, did you manage to achieve your lesson objectives?

   - How do you know? Can you provide some examples to illustrate the points that you make.
   - Can you provide examples of those moments/episodes in the lesson where you saw growth in students' thinking?
   - Can you provide examples of those moments/episodes in the lesson where equity in learning was achieved for all learners?
   - If not, who are the learners who were disadvantaged? (Boys? Girls? Other?)

2. What, if any, were the critical incidents in the class?

   - Why were these incidents critical for you?
   - What issues/questions do these critical incidents raise for you?
   - How, if at all, would you address them in the forthcoming lessons?

3. What are the major issues that you have learnt from this lesson regarding gender equity and problem solving?

4. How did the learners respond to your problem solving strategy?

Appendix B

SELF INVENTORY[9] TOOL

Introduction

The aim of this personal inventory is not to 'get answers' and then be evaluated in some way, but rather to use the various probes as stimuli for reflection, for reentering past experiences. It is the actions which are initiated that matter, not the answers as such. Consequently, if you find a particular probe does not stimulate recollection, then pass on to another (but later it may be worth pondering why there was no immediate response!).

For each of the following, imagine yourself in a typical situation and try to find some simple, some analogy that captures at least some aspect of your experience. Returning at other times and adding other analogies can be most instructive as the point is to gain access to the composite complexity of experience of professional practice, not to distil the complexity down to a few simplistic summaries.

Use the role and the people you have chosen as your first source of incidents through which to access typical in order to respond to the following probes. If a probe seems irrelevant, either transform it or leave it or consider a different aspect of your professional practice.

Name: ____________________________ **Gender:** ________________________________

Date: _____________________________ **School:** ________________________________

1. I see my role primarily as a ………………………………………………………….
2. I see my students as ……………………………………………………………………
3. Teaching mathematics is like ……………………………………………………….
4. Learning mathematics is like ………………………………………………………..
5. In your opinion, who finds mathematics easier, girls or boys? Please explain your response.

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6. 'Boys understand mathematics better than girls do'. What would you like to say based on your experience?

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7. 'Boys should be asked more challenging questions and girls simple questions while teaching mathematics'. Please share your reaction to this statement.

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[9] Adapted from Mason (2002). Researching your own practice: The discipline of noticing. London: Routledge Farmer Press and Amirali, M. (2007). Exploring students' conception of nature of mathematics. A quantitative research study report - Unpublished assignment of the PhD semester work. Aga Khan University Institute for Educational Development, Karachi, Pakistan.

8. ‘Boys have more use for mathematics than girls do when they leave schools.' Please comment on this statement.

9. Imagine that in your schools there are a few boys’ sections, a few girls’ sections and a few sections with girls and boys together (co-education). If you are given an option whom would you like to teach mathematics - only boys or only girls or both boys and girls together in a class? Please explain your response.

10. ‘Girls and boys both have the same natural ability to learn mathematics’. Do you agree with this statement? Please explain your point of view.

THE END

Appendix C

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Analysis of data from a gender perspective
A Pro forma

Read through the: a) field observation notes (Pakistan); b) pre and post observation post observation instruments; c) teacher interview data; d) teachers' self inventory and provide answers to the following questions. While observation data is for each teacher individually, the answers require the researcher to provide a statement which is *generally* applicable to all the action research teachers/observations.

1. What is the teachers' understanding of a gender sensitive curriculum? Has this understanding changed over the period of AR? How do you know?
2. What teaching strategies were mainly employed by the teachers for promoting gender equity pedagogy in the classroom?
3. Were the responses to questions 2 and 3 above common to all teachers? If not, where were the differences and why?
4. What issues for gender equity, if any, were reported by teachers (and others) in curriculum as planned and as practiced?
5. What examples, if any, were found where gender stereotypes in mathematics education (more broadly) were challenged or reinforced?

Reflective Memo
Drawing from the analysis above write a memo addressing the following:

1. What are the key gender issues with reference to mathematics education in your country?
2. In what ways did the AR promote among teachers an awareness of gender issues in science and mathematics generally and more specifically with reference to your country?
3. What were the teaching strategies being used by teachers to promote gender equity in mathematics?
4. How did the classroom environment facilitate/hinder boys' and girls' engagement in learning science and mathematics?
5. What was the change in the students' learning processes and outcomes as a result of the teaching in AR classrooms? Were there any differences noted in the achievement/learning patterns of boys and girls?

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