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LOWER SECONDARY SCHOOL STUDENTS' SCIENCE ACHIEVEMENT ACROSS GENDER: A STUDY FROM A RURAL AREA OF PAKISTAN

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ABSTRACT

This study aimed to investigate boys and girls students' achievement in Science at the lower secondary level in Pishin, Pakistan. A Science Achievement Test (SAT) developed as part of another research study (Qureshi, Bhutta, & Rodrigues, 2010) was adopted for this study. SAT was administered on 268 grade VIII students of eight lower secondary public schools in district Pishin, Balochistan. The findings indicated that the performance of girls was significantly better than their boys counterparts with a medium effect size (r = 0.29). Similarly, the girls maintained their significant performance in both multiple-choice questions and constructed response questions. These findings draw out some implications for policy, practice, and research.

Keywords: Gender differences; Science Achievement; Lower Secondary School

1. INTRODUCTION

Despite numerous efforts to achieve gender equity in Science education, girls are still under-represented in Science courses in many countries and often score worse than boys in Science Achievement Tests (Harwell, 2000; Hazari & Potvin, 2005), and it has been a growing concern in both the developed and developing countries. However, girls in the developed countries have got a greater access to Science, whereas in developing countries feminists still fight for the right of girls to attend schools or to have Science as a feasible option for girls (Barton & Brickhouse, 2006).

The trend in International Mathematics and Science Study (TIMSS) has demonstrated a gender difference in Science-related achievement across several countries and over time. Regarding achievement, differences are usually non-existent or small in the early school years, with larger differences beginning in junior high school and gradually increasing towards high school. The largest gender difference in Science achievements was found among the grade 8th students of the countries that had participated in the Third International Mathematics and Science Study (TIMSS, 2003).

The choice of teaching method has implications for students and their interest in Science, as Siraj (2002) in her study on Pakistani schools found that students have become passive listeners rather than active learners due to the traditional way Science is taught, and they struggle with lots of concepts without understanding them. As a result, the students learn Science through the rote-memorisation method, and Science learning has become a burden on the student in such a learning environment. Thus, when girls as well as boys do not get a supportive learning environment, they would lose interest in the subject.

The reason for lack of interest and participation of girls in Science may be that girls have different experiences outside the school from boys, which not only influence the skills, and knowledge they develop but also their understanding of the situation and problems (Murphy, 2000). Therefore, their competence is not only questioned but their preferred and earned ways of responding to the world are also reduced. Miller, Blessing, and Schwartz (2006) exhibited that "girls have low interest in Science, rather low ability" (p.377). Moreover, they state that "the rejection of Science is not related to the perception that it is too hard or not fitting the female gender role; they simply do not find it interesting or relevant to their life goals" (p.377).

Generally, when girls enroll in primary classes, they have the enthusiasm and motivation of learning Science, but their interest gradually declines as they go through the middle and high school Science learning (Dede & Yaman, 2007). At the lower secondary school level, girls perform well, but the evidence shows that in secondary school level, they select fewer relevant elective subjects (George, 2006). While Science education at lower secondary level is an important area and it is the gateway to professional and higher education (Government of Pakistan, 2009); girls tend to ignore Science in general. This has led to the situation where there are majority of boys doing Science better than girls at this level. Therefore, Science classes in general are dominated by boys while the girls go into reading language and Arts (MacDonald, 2005). The perceived poor performance of girls in Science leads to unpleasant developments, as it winds up the desire of those of them who would like to pursue careers in the sciences (Simpkins et al., 2006). This is because a pass at credit level in Science is required for admission into Science programmes in the professional colleges and universities.

Under-achievement and under-representation of girls in science have also been reported (Kahle, Meece, & Scantlebury, 2000; Labudde et al., 2000; Jones, Howe, & Rua, 2000; Mattern & Schau, 2002). The common theme found that the boys were high achievers in science as compared to girls. According to European EACEA (2010), as boys and girls grow older, the differences they have in achievement in other subjects tend to reduce except in the Sciences and Mathematics. The fear of Mathematics is often shifted to Science, which involves one form of calculation or the other (Mamlok–Naaman, 2011). However, not all concepts of Science involve calculations; mostly, concepts in physical Sciences require calculations. Onekutu (2002) agrees that in primary classes, there is no difference in the achievement of boys and girls in the sciences, but in the secondary classes, boys outperform girls in the areas that have to do with calculations. Results of the TIMSS (2003) for instance, demonstrate extensive gender differences in Science; Physics is the content area the results (in the middle school years) of which revealed significant achievement advantage for boys than for any other science content in a majority of participant countries. in more countries. Labudde, Herzog, and Nevenchwander(2000) assert that "across the separate science subject areas, the greatest number of statistically significant gender differences was found in physics, with boys consistently liking physics more than girls" (p.155).

In general, boys often outperform girls in Science achievement (Kotte, 1992; Lee & Burkam 1996; Smith, 1992); however, recent trends have encouraged a view that girls often achieve more highly than boys in Grade VIII Science achievement (Geier, Marx, Krajcik, Fishman, Soloway, & Clay-Chambers, 2008; Government of Pakistan, 2006; TIMSS, 2007; Weaver-Hightower, 2003). On the other hand, some studies also reported no gender difference in Science achievement (e.g. Ma and Wilkins; 2002).In the 1970s and 1980s, girls were behind boys in a variety of academic performance measures, specifically in Science. However, in the last twenty years the general trend of girls outperforming boys in academic achievement and boys performing worse than they did 20 years ago (Kafir, Krista, 2007).

The discussion on the gender differences in Science achievement highlights the issues that could erode the interest of students towards learning Science despite the fact that it is the prime need of the time. Due to the gender-isolated cultural practices, as discussed above would be more constraining for girls and the likelihood of the girls losing their interest towards learning Science increases. Thus, we need to encourage girls to study Science in addition to providing all students with better teaching and learning opportunities for Science, because Science is not only important for the job market but also has an important role in producing Scientifically literate people who can adapt well to the ever-changing global world.

Furthermore, the debate about gender differences has made it evident that although learning Science is a basic right of both genders, for many decades Science has been a male domain. Moreover, girls have low participation in Science despite having talent. This is not an issue of biological differences or inherent cognitive differences between genders (Murphy, 2000); rather the issue is how Science is presented to girls in classroom and outside the class. The way Science is taught to girls can cause low achievement; and consequently, it can then lead to a decline in the number of girls studying Science. A further issue is the isolation of girls from Science (Kahle et al., 2000), especially from the physical Sciences, and in particular from Physics.

Literature review revealed that a number of studies have been carried out to explore gender differences in science achievement and attitude. However, a majority of these findings are reported from the developed world. Though a recent trend of conducting child outcomes studies in Pakistan (Government of Pakistan, 2006; http://www.peas.gop.pk/) is encouraging there is still a need to conduct such studies in various areas especially in the rural context in order to explore students' learning outcomes in general and gender differences in particular. Keeping in mind this gap, the current study was planned to investigate lower secondary school students' science achievement across gender in Pishin-Pakistan. Pishin is a rural district of the Province of Balochistan. This paper presents a part of a larger study which was carried out as part of the Masters' thesis of the first author. The paper will focus on the following research question.

What is the difference between boys' and girls' Science achievement at the lower secondary schools in Pishin, Pakistan?

Explanation*: Science Achievement Test (SAT) was used to measure students' performance in science. SAT was developed as part of a large-scale study which was carried out in urban and rural areas of Pakistan (Qureshi, Bhutta, and Rodrigues, 2010).*

2. METHODOLOGY

This section discusses the research methodology employed to conduct the study. It includes population, sampling procedure and sample size, the research instrument (Science Achievement Test) and the procedure for test administration as well as reliability and validity of the SAT instrument. It also presents the data analysis procedure.

2.1 POPULATION AND SAMPLE

The target population of this small-scale study comprised all the grade VIII Science students studying in public schools in district Pishin, Pakistan. Pishin district was selected due to accessibility within the limited time available for data collection as it was not possible to travel in remote areas of Balochistan to access schools. Keeping in consideration the available time and resources 4 schools from each gender (boys and girls) provided a suitable number of students to conduct statistical comparisons. The sample was selected from two strata (i.e., boys and girls) schools. Four boys' and four girls' schools were selected randomly. The total sample size comprised 268 students of 8th grade of which 135 (50.4%) were girls and 133 (49.6%) were boys. Gender ratio of girls and boys were almost similar in boys and girls public schools.

2.2 THE RESEARCH INSTRUMENT: SCIENCE ACHIEVEMENT TEST

In this study a Science Achievement Test (SAT) was adopted to explore the students' achievement in Science. SAT was developed as part of the institutional research which was led by University faculty (Qureshi et al., 2010). The University team reviewed National Curriculum in order to draw major themes to develop test items. Most of the items were adapted from the Trends in Mathematics and Science Studies (TIMSS), while some items were developed by the team to represent themes in the National Curriculum.

SAT encompasses 35 items comprising 25 Multiple-choice questions (MCQs) and 10 Constructed-response questions (CRQs) that address a broad range of lower-secondary science concepts, implies factual understanding and reasoning skills of students. The SAT carries 35 marks in total including 25 for (MCQs) and 10 for (CRQs). The marking scheme for multiple-choice questions was assigned 1 mark for correct answer and 0 for incorrect answer. Furthermore, the marking scheme for constructed-response questions was assigned 1 mark for correct answer, 0 for incorrect answer, and 0.5 marks for a partially correct answer.

The students taking part in this study were from the government school system where the medium of instruction is Urdu. Therefore, to make the instrument respondents-friendly it was also translated into Urdu (the national language of Pakistan).

Content validity was established by the authors of SAT (Qureshi et al., 2010). In order to establish content validity the instrument was sent to the national practitioners and educators of science education (n=4). They were asked to rate importance of each item for the Pakistani context on a 5-point scale in light of their understanding and experience of science curriculum and textbooks. Their responses helped to gauge the importance of the test content for the Pakistani context. They were also asked to share their feedback on other aspects of the test including language, accuracy, and clarity. The overall analysis of items scoring revealed that a mean score for 70% (n=20 items) were rated 4-5 of the items. While a mean score for 29% (n=10 items) fell between 3.0 and 3.9 of the items. Test was revised in light of reviewers' feedback.

SAT was field tested in urban (i.e. Karachi) and rural (Chitral, Gilgit-Baltistan) areas of Pakistan as part of the large-scale child outcome study (Qureshi et al., 2010). The reliability coefficient of SAT was 0.75, which is above 0.70, an optimal alpha value (Field, 2005; Singh, 2007). SAT has demonstrated satisfactory psychometric properties in a large-scale study for which the sample was recruited from urban and rural settings of Pakistan. While the researchers were aware of the importance of piloting the instrument in the context of the current study the time frame was not viable to include a component of piloting. This is a limitation of the current study.

2.3 PROCEDURE OF TEST ADMINISTRATION

A direct administration method was selected for this study to ensure maximum response from research participants. Under this procedure, the researcher was present when the achievement test was being completed by the group of research participants (i.e. students in a classroom). This method of administration helped the researcher to get a higher response rate (Gorard, 2003; Muijs, 2004). The students filled the Science achievement test under examination setup in their classrooms. Instructions were kept the same for all the students to avoid possible influence on their responses. Moreover, students' right to withdraw from the research study was also shared with them.

2.4 DATA ANALYSIS PROCEDURE

Collected data were analysed using the latest available version of the statistical software Statistical Package for Social Sciences (SPSS 19.0).

The purpose of the study was to explore the difference in lower secondary school students' differences across gender. The analysis was a step-wise process. *Firstly*, all tests were marked before entering data using the scoring scheme as presented in table 1. An answer key was developed for both MCQs and CRQs to guide the marking process. In order to develop the answer key, textbooks and TIMSS answer guide were consulted.

Table 1. Marking scheme for SAT

Part	Correct	Incorrect	Partially correct
MCQs	1	0	Not applicable
CRQs	1	0	0.5

Secondly, a template was developed in SPSS for data entry. Responses were coded according to the scoring scheme (i.e. correct =1, incorrect = 0, partially correct= 0.5). Dummy variables were coded for categorical indication; for example, male and female were coded as 0 and 1, respectively. Missing data were coded as 99. Data entry was started after marking all papers. *Thirdly*, the entries were reviewed for errors by running frequencies*. Fourthly*, new variables were computed including the mean score fro MCQs and CRQs. These variables were then explored further for psychometric properties (normality, homogeneity of variance). Data were found to be normal. In addition, mean and standard deviation were computed for both groups (male and female) for initial descriptions. *Finally*, test of comparisons (independent t-test) was used to compare students' score across gender both for MCQs and CRQs. Furthermore, effect size was computed to find out the magnitude of difference between the two groups.

3. RESULTS

This section presents results of the study which are organised under two subsections: (i) overall comparison; and (ii) comparing scores of MCQs and CRQs across gender.

3.1 COMPARISON OF OVERALL SAT SCORES ACROSS GENDER

In order to explore how students scored on the Science Achievement Test across gender, a total mean SAT-score was calculated for the girls and boys. Figure 1 reveals that girls outperformed (M=20.34, SD= 5.01) boys (M=17.31, SD= 4.87).The difference was found to be statistically significant [t (266) = 5.020, $p < 0.001$], with a medium effect size[1] (r = 0.29).

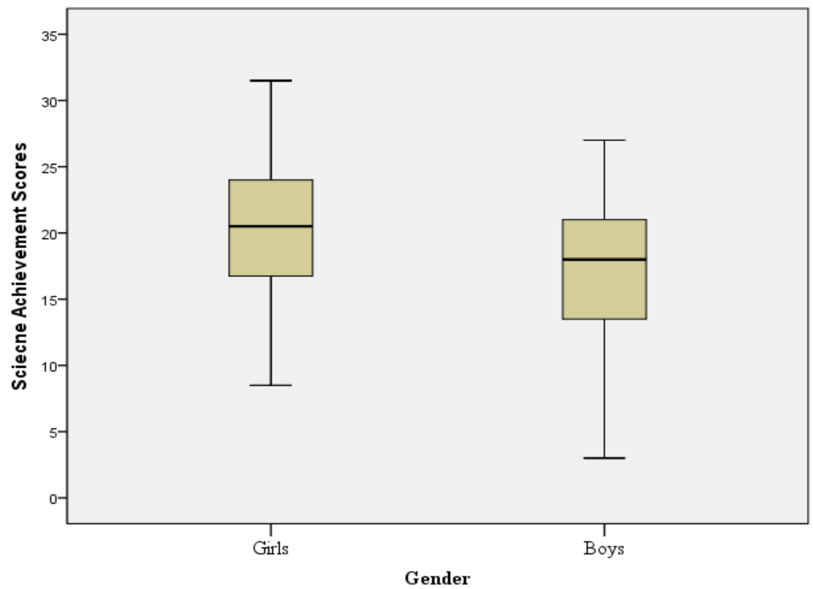

Fig. 1. *Distribution of total SAT score across gender*

3.2 COMPARING SAT SCORE BY MCQS AND CRQS ACROSS GENDER

Further analysis was carried out in order to explore how girls and boys have scored on MCQs and CRQs on the Science Achievement Test, the total mean MCQs and CRQs scores were computed for gender. Figure 2 presents that girls have scored comparatively higher in MCQs (M=15.69, SD= 4.27) than their boys counterparts (M=14.10, SD= 4.00). The difference was found to be significant [t (266) = 3.14, $p < 0.01$], with small effect size (r = 0.19). Girls have scored higher in CRQs also (M=4.64, SD= 1.79) as compared to their boys counterparts (M=3.20, SD= 1.70). However, both the girls' and boys' achievement in CRQs was lower as compared to scores on MCQs. The difference was found to be statistically significant [t (266) = 6.75, $p<0.001$], with a medium (r = 0.38) effect size.

[1] Small, medium and large effect size is 0.01, 0.3, and 0.5 respectively (Field, 2005).

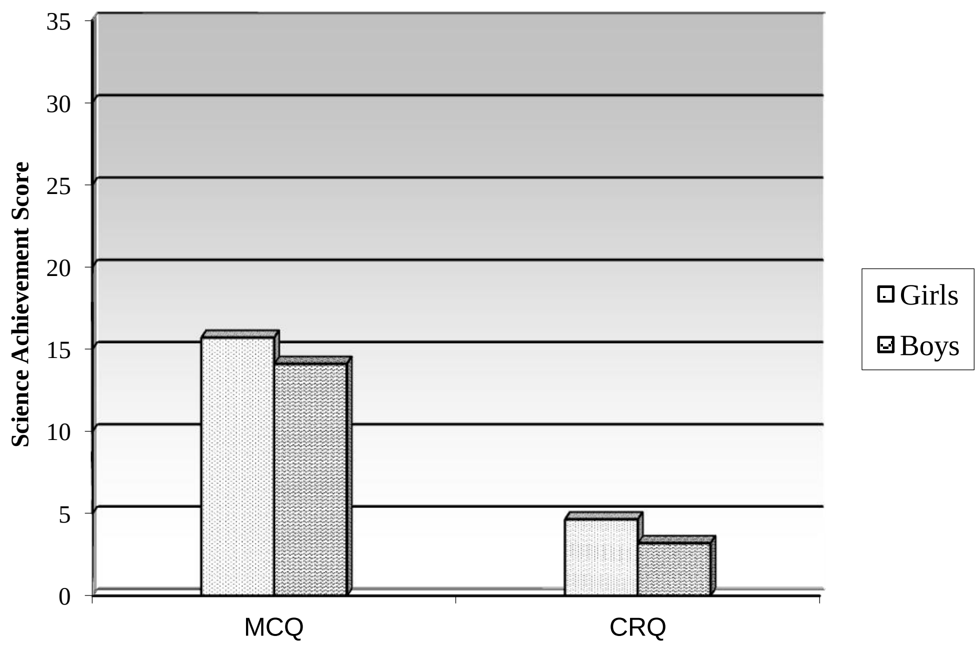

Fig. 2. *Distributions of Mean score of the girls and boys on MCQs and CRQs*

Hence, based on the results of this study, it can be concluded that girls' performance was significantly better than boys in Science Achievement Test.

4. DISCUSSION AND CONCLUSION

This research study provides a unique look at the Science achievement across gender. It investigated whether or not boys perform better on a Science Achievement Test than girls. Traditionally, there has been a common perception that boys do better than girls in science. Conversely, recent trends have encouraged a view that girls often achieve more highly than boys in science. This research study results are in favour of the recent trends.

Gender differences in Science Achievement Test were observed as girls achieved significantly higher scores than boys. This finding is consistent with recent research of the national study conducted by NEAS (2008) found that the girls, significantly outperformed boys in Grade Eight Science subject (Government of Pakistan, 2006). In addition, for the international study of sixty countries, there were statistically significant differences between the Grade Eight Science achievement scores of girls and boys, which favoured girls in many countries (TIMSS, 2007). Moreover, another research study that looked into children's achievement test in implementing inquiry-based Science curricula in the Urban context found that the girls outperformed boys in children' achievement of Science content (Geier et al., 2008). Contrary to this, a previous study in Grade Eight Science found no gender differences in achievement (Ma & Wilkins, 2002); however, in an international comparative study of Science achievement of 10 nations, Kotte (1992) found significant differences across nations in Science achievement, which favoured boys as the girls performed more poorly than boys. Moreover, this study results failed to support findings of earlier studies (Jegede& Inyang, 1990; Lee & Burkam, 1996; Smith, 1992; TIMSS, 1999) found that boys outperformed girls in lower secondary Science achievement.

The findings of this study *"girls perform better than boys in Science achievement test with magnitude 0.29*", which somehow shows the interest of girls students in learning Science. Jones et al. (2000) assert that girls and boys have different interests in learning science. Girls have typically possessed more interest in studying Science than boys in beginning and early elementary schools (Kotte, 1992). There are several theoretical implications associated with the current findings. Significant differences favouring girls in lower secondary Science may provide support to cognitive and informative processing; they suggest that innate differences between girls and boys cause differences in earlier Science concept development (Naglieri & Rojahn, 2001). Significant differences found in the current study might not be found at every grade level.

The results have shown that girls have not only performed better in MCQs but their performance was also better in the items that directed children to give a reason (constructed-response questions) to support their answer. Kjaernsli, Angell, and Lie (2002) present that the constructed-response questions provide enriched insight into children's thinking, and their conceptual understanding. The low performance of boys in constructed-response questions revealed their lack of conceptual understanding, application of learnt knowledge in daily life situations, as well as analysis and problem solving skills. Furthermore, boys did not manage to integrate and develop a link between distinct yet interlinked concepts.

Moreover, connecting Science to students' everyday-life experiences has been an important issue in science education and this should be included in Science lessons. Students' queries during the administration of test reveal such issues for example, a girl asked *"if she could write the answer of item number 6 (healthy growth of plan)" based on her practical experience, because she has planted a seed in a pot at home a few days ago. In addition, another child asked "if she could write the answer of the concept of how cold/flue spread, based on her own understanding".* The better performance of girls in this research study revealed their better conceptual understanding, application of learnt knowledge in daily life situations, as well as analytical skills. Campbell and Lubben (2000) assert several reasons for incorporating everyday-life experiences of users and focusing on everyday-life applications of Science. *Firstly*, everyday-life experiences are a way to make Science meaningful to students. *Secondly*, students are to be educated as scientifically literate citizens, everyday-life theme related to Science is necessary. *Finally*, from the constructivist point of view on learning students' alternative conceptions derived from their everyday-life experiences before the formal instructions have been seen as a starting point in teaching. However, isolating the school Science from students' everyday-life could make students develop two unconnected knowledge systems related to Science: one is used to solve Science problems in schools, and the other is used for their everyday-lives. Having said that, a question which needs further exploration is the difference between girls and boys in making explicit links between science and daily life. How come boys did not raise such questions as girls?

The overall, performance of students in this research study shows that the boys are not competitive with girls in Grade VIII Science achievement. Also, disparity among students in Science performance shows that either the students were not receiving similar quality of education or they were not learning enough to be competitive. The performance of girls and boys were significantly different with girls outperforming boys in both knowing and reasoning domains.

This research study explored whether or not boys and girls perform differently on Science Achievement Test. Though the girls sustained their high-performance in all aspects of Science Achievement Test, their performance on CRQs indicates that students' conceptual understanding and scientific reasoning skills of Science concepts still needed to be addressed. Therefore, much more importance could be given to conceptual understanding keeping in view the already developed factual knowledge and reasoning skills of students rather than paying attention to memorization. Findings of this study certainly have implications for policy and practice. Some of these implications are presented here:

- Keeping in view the results of this study, more emphasis needed to be given to develop students' conceptual understanding and scientific reasoning skills of science. This would be achieved when students are involving in questioning, discussion, and demonstration.

- The results of this study indicated that the boys compared to girls do not apply their science learning in daily life situations. Therefore, it is recommended that there is a need to increase students' accessibility to science in connection with everyday life.

- Results of the study generate opportunities for further research. For example, it would be useful to explore classroom practices in order to analyse teaching learning process with a 'gender frame work'. The nature of relationship between classroom practice and students' learning outcome would help to explain students' performance and gender difference from a practice point of view. This research study suggests the need for additional research that investigates teachers' classroom practice across gender. Classroom practice would help to capture processes.

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