Problem Solving Performance in Mathematics: A survey of Secondary School's Students in Pakistan

Dr Amir Zaman[1], Dr Riasat Ali[2]

Department of Education, Abdul Wali Khan University Mardan
amirzaman69@yahoo.com

Abstract: The main aim of this study was to assess problem solving performance of grade 9th students. A test of reasoning was administered to a sample of above 500 hundred. The results show differential performance of the students. Item wise performance with background variable as school sector shows that performance of private schools students was significantly better than students of public schools. Similarly male and urban students performed well than female and rural students respectively. Interaction analysis of gender, rural urban divide shows that some items show interaction effect by behaving differently in response to background variables.
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1. Introduction

Problem solving ability is important in enabling students to be independent thinkers and to find Solutions in all areas of life (Arora, 2003). The National Council of Teachers of Mathematics has recognized problem solving as one of the five fundamental mathematical process standards (NCTM, 2000). Problem solving is now considered a great source of attention and foundation for all mathematical activities (Reys, Lindquist, Lambdin, Smith, & Suydam, 2001). Burn (2000) is of the view that problem solving ability is necessary to function in our complex and changing society. Achievement in problem solving across mathematics and science is strongly related to achievement in mathematics (TIMSS, 2003).

Johnson (1984) during a series of experiments on students in mixed-gender groups numbering 20 to 50 in which subjects were allowed exactly 3 minutes per problem has reported male advantaged, with a median value of 35% over nine experiments. Similarly Bessoondyal (2005) has also reported significant gender differences in problem solving in favor of boys. Battista (1990) conducted a study and reported that male significantly outperformed female in their geometrical problem solving score. A study was conducted by Manger and Gjestad (1997) in Norway comparing males and female about mathematics achievement in which 49 third-grade students. The results suggest that there is a significant effect of gender favoring boys in measurement problems, fraction problems, geometry problems, and verbal problems.

In contrast, other studies show the opposite trends for example Fennema (1978) conducted Romberg-Wearne Problem Solving Test (R-W) (Wearne, 1976), on the 1320 students from 6th-8th grade. He found that girls were slightly doing well in problem solving. Carr & Jessup (1997) found limited evidence on problem solving gender wise that there may be some gender differences in problem-solving strategies, girls tending to use counting while boys relied on mental strategies. Gallagher and DeLisi (1994) in his study found that females had the tendency to use more conventional (commonly taught) strategies, against males who tended to use more untaught strategies but overall there was no gender differences in achievement. Randhawa (1987) conducted a study in Canada for grades 4, 7 and 10 and found that in the Mathematics Problem Solving sub skills analysis; there was a trend from a non significant sex difference at Grade 4 to a significant sex difference at Grades 7 and l0.

While some studies have reported no gender differences in problem solving construct e.g. Fennema et al (1998) conducted a three years longitudinal study with a sample of 44 boys and 38 girls. She conducted five interviews, besides considering other variables gender was also taken as determinant. Results showed that difference was not significant when performance of boys and girls was compared during these three years for number facts, addition/subtraction, or non routine problems. In grade 3, boys solved significantly more extension problems than did the girls. However, for problem solving construct there were strong and consistent gender differences in terms of using strategies to solve problems. Girls were found to use more concrete strategies like modeling and counting while boys showed tendency to use more abstract strategies reflecting conceptual understanding.

Moreover at the end of this longitudinal study strategies used by girls were more standardized than boys used. On the other hand problems where extension procedure was required, boys were found to outperformed girls. El Hassan (2001) found no gender difference in problem solving in 9 and 13 grades.

Most of the studies have reported superior performance by male in problem solving e.g. (Johnson,1984; Bessoondyal, 2005; Battista, 1990;

Terje & Rolf, 1997) while other reports better performance by female like (Fennema et al, 1978; Carr & Jessup, 1997; and Gallagher & Delsi, 1994). In contrast two studies Fennema (1998) and El Hasan (2001) have found no gender difference in problem solving.

All of the above studies have contributed well to the literature of study but almost all have used multiple choice tasks in solving routine word problem leaving the room for task based assessment, with justification of their solution, to assess students ability in problem solving in broader context of location, school sectors and other context. Therefore this study focuses on students' problem solving ability with gender, school location and school sector as background variable. Further more rigouros statistical analysis using t-test, eta square and ANOVA has been applied in contrast to earlier studies described above.

Methodology:

The study used survey approach and population for the study was 371000 students enrolled in 2703 secondary schools.

Sample For The Study: A multi staged probability sampling techniques was used to draw sample from population for quantitative data collection. The sample size was decided on the basis of sampling error of 4% with 95% confidence interval and assuming that a student has 30% chances participating in the studies. Following this criteria given by Fowler (1988, cited in Creswell, 2005, p.583) total sample for the survey was decided to be 500 subjects or beyond. Proportionate approach in sampling was adopted as illustrated in the table 1 given below.

Table 1. Composition Of The Sample

	Sector Wise		Gender Wise		Location Wise	
	Public	Private	Male	Female	Rural	Urban
%age	50	50	70	30	70	30
Students in sample	289	289	405	173	405	173

Tool: Data was collected thorough a test with six constructed response items. Content validity was ensured through expert opinion and construct validity was check through factor analysis. Reliability of the instrument was found to 0.90.

Result And Discussion:

Item wise and scale wise performance was analyzed using mean, standard deviation, minimum and maximum to provide an overview of students' performance on each item and on the scale as whole. More item reliability coefficient was also determined.

Table 3 below shows the details.

Table 2. Item Statistics for Problem Solving sub scale

Mean Std. Min Mix Cronbach's Alpha dev if item deleted					
Item 1	2.03	1.44	0	4	.708
Item 2	1.50	1.46	0	4	.707
Item 3	1.58	1.49	0	4	.692
Item 4	.94	1.35	0	4	.682
Item 5	1.60	1.43	0	4	.675
Item 6	1.29	1.36	0	4	.698
Scale	8.95	5.54	0	24	.786

Table 2 shows that the mean scores for items in problem solving scale ranged between 0.94 and 2.03 with overall mean of 8.95 with maximum score of 24. Item 4 was found to be the difficult item with mean score of 0.94, while item 1 was the easiest item in the problem solving scale with mean score of 2.03., this item was about completing a table with different simple arithmetic operations.

Gender wise comparison in problem solving performance was made using paired sample t-test to know the students performance across gender. Cohen's D value was also calculated to elaborate the mean difference. Analysis is given in table 4 below.

Table 3. gender wise analysis of performance in problem solving

Scale	Male Mean	Std. Dev	Female Mean	Std. Dev	t-value	Sig.(2-tailed)	Effect size Cohen's d
Problem Solving	9.98	5.991	8.56	5.208	2.137	0.035*	0.253

The table 3 shows that there is significant difference between the mean score of male and female with male outperforming their counterparts. However Cohen's D value of (0.25) shows that this effect is modest in size.

Similarly location wise comparison was also made using t-test and Cohen's D value. The results are given below in table 4.

Table 4 location wise analysis of performance in problem solving

Scale	Urban Mean	Std. Dev.	Rural Mean	Std. Dev.	t-value	Sig. (2-tailed)
Problem solving	9.5	.63	6.89	5.26	4.818	.000**

The table 4 shows that there is significant difference between the mean score of urban and rural students with urban outperforming their counterparts. Further elaboration by Cohen's D value of (2.54) shows that this effect is strong in size.

Table 5 sector wise analysis of performance in problem solving

Scale	Public Mean	Std Dev	Private Mean	Std. Dev	t-value	Sig.(2-tailed)	Effect size Cohen's d
Problem Solving	6.82	4.680	11.27	5.425	8.846	0.000**	0.87

The table 5 shows that there is significant difference between the mean score of private and public school's student with students from private schools outperforming their counterparts. However Cohen's D value of (0.87) shows that this effect is moderate in size.

Any interaction between the independent variables i.e. sector, location and gender with problem solving was put into multivariate analysis for possible interaction. The table 6 below shows the analysis.

Table 6 Interaction between gender, sector and location

	Location & Sector Eta^2	Sector & Gender Eta^2	Location & Gender Eta^2
Problem solving	.000	.001	.070**

Table 6 shows that there is significant interaction effect between the gender and location on problem solving performance of the students. Similarly interaction effect was also significant between sector and location.

Further eloboration through interaction graph reveals that male in the urban schools were doing well significantly than rural male in problem solving while this trend was reversed in case of female students where rural students were better than urban female students.

Interaction effect was further investigated using interaction graphs shown below which illustrates that rural students in private schools were better than urban students in private schools for problem solving while the mean score of students from different location in private schools had almost the same level of achievement. In case of public schools trend was reverse and the mean score of urban students was higher than the mean score of rural students in problem solving.

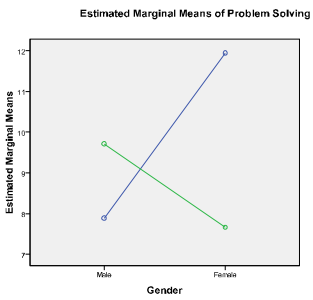

Fig.1 Interaction between gender and Location

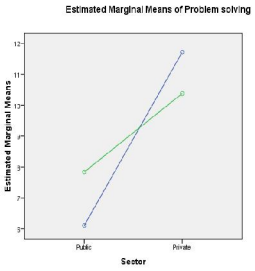

Fig.2 Interaction between Sector and Location

Discussion

Better mean score of private schools' students in mathematical thinking and mathematics achievement and also in the individual scales of mathematical thinking indicates a big edge of private sector probably due to better supervision by private schools over the teachers.

Eta squared values of interaction effect between gender and location for problem solving, shows that there was significant ineteraction effect between gender and location.

In relation to location, there were significant performance differences in problem solving with urban students outperformed rural students. Urban areas have often better population in terms of socio economic status and literacy rate so the students here also have the opportunities to get private coaching which is a popular culture in Pakistan. Urban students have frequent interaction with educated people and thus gets motivated for education in contrast to the students of rural areas where they are mostly engaged with parents in farming and other jobs and thus do not get much time for study and lagged behind their urban counter parts.

Most of the children of private come from educated and richer families, administration and learning environment would vary to some extent. Students of private schools outperformed their public counterparts significantly in problem solving. Possible reasons of better performance by private schools' students may be due to better facilities in private schools like qualified teachers are available to private schools because the administration of private school is

autonomous in recruiting teachers according to their needs and merit against the public sector where seniority play role in recruitment and promotion. Further private schools can terminate their teachers when they are not satisfied from their performance which leads to a pressure on the teachers in private schools and they work hard to show progress. Public schools follow fixed schedule of timing set by secretary of education particularly seasonal vacation where as private school are flexible and thus avail maximum teaching days in a calendar year. Private schools teachers have better teaching practices and assessment schedule where mostly monthly test are popular traditions and progress report is sent to their parents. Parents of students in private schools are not only educated but pay direct cost in term of monthly and annual fees so they keep an eye on their children progress which not only proves motivation for students but also works as extra check on school administration. The culture of competition among the private schools mostly for economic reason is additional advantage to the students in private schools and they are given attention to gain refute for their schools by obtaining high score in exams.

Interaction effect between gender and school location from ANOVA results show that there were significant interactions between gender and location in problem solving. Male in the urban schools were scoring better significantly than rural male in problem solving. The possible reasons for urban males having better performance than male students in rural locations are that urban male students have access to a variety of private coaching centre and they can learn what they on the other hand rural students need have limited chances for extra coaching. Moreover better socio economic of urban population favors their children to give more time for study and not involved them with parents in business where most of the people are doing business or offer services and so their children have less chances to be involved. On the other hand rural students spend considerable time with helping their parents mostly engaged in farming related jobs and animals catering. In contrast, females in rural schools had higher mean scores than those in urban schools. Perhaps females in urban areas are more likely to go out to places of entertainment or visit their female friends than females in rural locations. Moreover female in urban areas are more passion addiction, often play games on computers and waste time on internet chatting and thus suffers in their attention to academic achievement. On the other hand girls in the rural areas do not visit their peers and relatives frequently who are often distantly located due to shortage of resources like traffic availability. Similarly passion trends is not much common in villages and thus these girls pay more attention to study and thus gets more score than their urban peers.

Gender and sector were both combined as independent variables with problem solving as dependant variables but no interaction was observed. Better achievement for female students in private sectors in comparison to female students of public school is consistent with t-test analysis and can be attributed to teachers' availability, effective supervision in private schools. Female students as explained earlier do not get much attention of their parents due to traditional and conservative constructs of the societies and therefore those girls who get attention may work hard to fulfill the aspiration of their parents. Good academic achievements by girls have considerable effect on their future life like life partner and this works as additional motivation for them and taking their achievement serious they get better marks.

Problem solving was also significant in interaction analysis between sector and location where urban students in public schools were outperforming their public counterparts. This variance is possibly due to better teachers in urban areas where most of good teachers not only prefer to work in urban areas but also work hard to maintain their reputation. Moreover urban schools are being frequently and easily visited by education authorities so the supervision is far better than rural schools besides good facilities like playgrounds, laboratories and private coaching centers. In contrast students of private schools were doing better in problem solving. The possible explanation can be that in rural areas socio economic status of people is not comparable to that of urban areas and the parents spends money on those children whom they expect a return in high achievement. Moreover situation of rural schools is worse than urban public schools in terms of facilities including teacher's availability and thus students in private school give better results than public at rural areas.

Recommendation; A larger value of standard deviation in case of mathematical thinking in comparison to mathematics achievement suggests that task based assessment with emphasis on reasoning are more effective than tests with items that assess procedural knowledge, in differentiating the students. Therefore students' assessment should include, at least, a part of such items. This development will help the teachers to better understand their students.

Favorable interpersonal interaction between teacher and students and between students should be developed through friendly discussion and collaborative assignment of challenging problems relating to daily life so that to foster students mathematical thinking and consequently better achievement in mathematics.

Students should not be discouraged during question answer process in the classroom and their faulty mathematical reasoning should be utilized for learning. Their poor reasoning should not be rewarded negatively.

This study may be replicated on a different sample like other parts of the country. The present tools used in this study can be used by researcher with little or without modifications. Thus prospective study may investigate and verify the generalizability of this study.

Similar study can also be conducted for other level of the students' like primary and elementary level. In such case the researcher need to have a look on the model of mathematical thinking and develop new tools.

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