

Effect of Problem Solving Ability on Mathematics Achievement among Secondary School Students: An Empirical Study

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ABSTRACT

The purpose of the present study is to investigate the mathematics achievement of secondary school students in relation to problem solving ability and gender. Descriptive survey method was used. Problem Solving Ability and Gender were treated as independent variables whereas Mathematics Achievement was treated as dependent variable. A sample of 400 secondary school students was selected through multi-stage random sampling technique. Problem Solving Ability Test for school students (PSA) by Dubey (2011) [5] was used to assess the problem solving ability of the students. Mathematics Achievement Test (MAT) developed by Singh and Jaidka (2015) [18] was used to assess the mathematics achievement of secondary school students. The obtained data was analyzed using Two Way ANOVA with 3x2 factorial design. Levene's Test of Homogeneity of Variance was also applied to test the assumption of homogeneity of variance for ANOVA. The findings of the study revealed that problem solving ability and gender has significant main effect on the mathematics achievement of the secondary school students. However, no significant double interaction effect of problem solving ability and gender on mathematics achievement of the secondary school students was found. Thus, efforts should be made to help the students to improve their problem solving ability which will help them in improving their mathematics achievement. Workshops and seminars should also be organized in all educational institution to guide the students about the various techniques to enhance the mathematics achievement. The findings of the present study has an implication for teachers that they should use the appropriate classroom techniques, methods and tools so that better problem solving ability can be accomplished.

1. Introduction

With a change in scenario and thrust on modern materialistic achievement, the education has undergone a drastic change. A person's education has become an indicator of his status in society. The scores in examination decide about the level of intelligence whereas the education is linked to the life chances, income and well being (Battle Lewis, 2002) [4]. In modern age of competition and perfection every human being strives for success. For student, success implies academic success which should be well matched with pillars on which the future success of their lives stands. In our society, academic achievement is considered as a key criterion to judge one's total potentiality and capacity. Hence, academic achievement plays a significant role in education as well as in learning process.

It is also the status of individual's learning and his ability to apply what he has learnt. Academic achievement is not a uni-dimensional but a multi-dimensional phenomenon.

No two individuals are same. Individuals of the same age group and even of the same grade are found to differ from each other in their abilities and academic achievement. The same individual may differ in his or her academic achievement with the change in time or with the change in their maturity level. "Academic achievement is the knowledge obtained or skills developed in the school subjects usually designed by test

scores or marks assigned by the teacher" (Good, 2009) [6]. "An achievement is all an obtaining for an exertion or an accomplishment of an effort" (Vyas & Gunthey, 2017) [19]. For a student, academic achievement paves the way for getting a valuable job and also for the attainment of personal satisfaction as well as social recognition. "Academic achievement represents performance outcomes that indicate the extent to which a person has accomplished specific goals that were the focus of activities in instructional environments, specifically in school, college and university. There are many factors which affect academic achievement viz. intelligence, personality, motivation, school environment, heredity, home environment, learning, experiences at high school, interests, aptitudes, family background, socio economic status of the parents and many more other factors influenced the academic achievement. Despite this, one of the major factors of education is the ability of problem solving that affect the academic achievement. Problem solving is the key to success and has been regarded as the most significant aspect of human behavior. Problem solving ability plays an important role in the academic achievement of students and has been received broad public interest as an important competency in modern societies. In educational large-scale assessments, paper-pencil based analytical problem solving was included first (Programme for International Student Assessment, PISA, 2003(OECD, 2003) [14]. Enhancing students' problem solving capacity is one of educational psychology's greatest challenges and is a major demand placed on any educational institution (Mayer and

Wittrock, 2006) [13]. Bearing this in mind, it is not surprising that educational large-scale assessments (LSAs) around the world have recently identified problem solving as a core domain that complements classical literacy concepts in secondary school subjects. Gupta, Pasrija & Kavita (2015) [8] revealed that problem solving ability had a significant effect of academic achievement of high school students. Pathak (2015) [15] reported that relationship between problem solving ability and achievement is highly positive. Similarly, Maheswari and Benjamin (2015) [12] also examined the significant relationship between problem solving ability and mathematics achievement. Senthamarai, Sivapragasam and Senthilkumar (2016) [17] showed that level of problem solving ability in mathematics of secondary school students is average. Gupta, Kavita & Pasrija (2016) [7] examined the significant interaction effect of locality and problem solving ability on the academic achievement of the students. Bala and Shaafiu (2016) [3] revealed a positive correlation between academic achievement and problem solving ability. Although a number of empirical studies have been conducted to study the influence of various demographic factors on the mathematics achievement, yet a very few studies have been conducted to explore the mathematics achievement of secondary school students in relation to problem solving ability and gender. No study is there to study the interaction effect of problem solving ability and gender on the mathematics achievement of secondary school students. This fact encourages and led the investigator to make an attempt to study the mathematics achievement of secondary school students in relation to problem solving ability and gender.

2. Variables used

- **Dependent Variable:** Mathematics Achievement
- **Independent Variables:** (c) Problem Solving Ability [High, Average and Low]; (b) Gender [Male & Female]

3. Objectives of the study

1. To study the main effect of (c) Problem Solving Ability [High, Average & Low] and (b) gender

[Male & Female] on mathematics achievement among secondary school students.

2. To find out the interaction effect of problem solving ability and gender on mathematics achievement among secondary school students.

4. Hypothesis of the study

H₀₁ There exists no significant main effect of (c) Problem Solving Ability [High, Average &Low] and (b) gender [Male & Female] on mathematics achievement among secondary school students.

H₀₂ There exists no significant interaction effect of problem solving ability and gender on mathematics achievement among secondary school students.

5. Methodology

In the present study, descriptive survey method was used. The independent variables i.e.

Problem Solving Ability [High, Average &Low] were divided into three levels and gender (Male & Female) were divided into two categories.

Sample

At the outset, a sample of 400 secondary school students was selected through multi-stage random sampling technique. The sample was further classified on the basis of their problem solving ability and gender. As per the norms given in manual the problem solving ability test has been classified into (high, average and low) group with respect to male and female students. The strength of high problem solving ability preferred students was 113, average problem solving ability preferred students was 181 and low problem solving ability preferred students was 106. In this way, as per the requirement of the 3x2 cells of the paradigm, distribution of cells for analysis of interaction effect of problem solving ability and gender on mathematics achievement has been illustrated in fig 1.

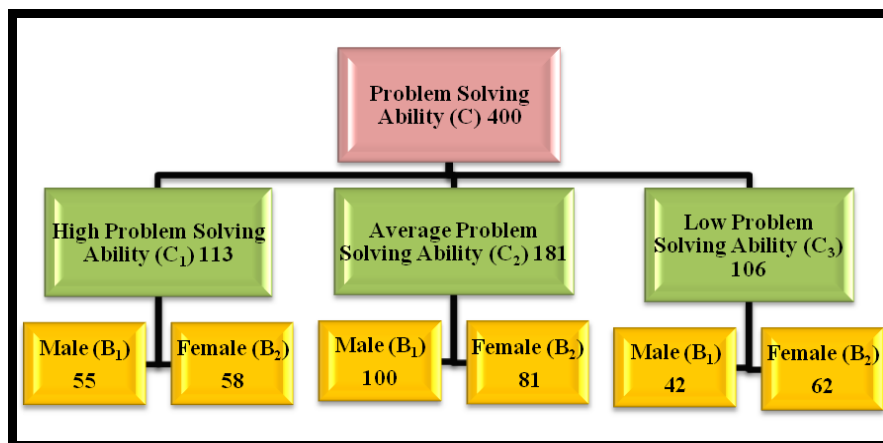


Fig. 1: Schematic Layout of 3x2 Factorial Design for Effect of Problem Solving Ability and Gender on Achievement in Mathematics of secondary school students

Tools Used

Mathematics Achievement Test (MAT) developed by Parmvir and Jaidka (2015) [18] was used to assess the

mathematics achievement of secondary school students. The test has 58 statements under 4 dimensions which pertain to the mathematics achievement of the students. The reliability

coefficient was determined by Test-Retest method. The reliability coefficient was found to be 0.78. The correlation coefficients reveal that the mathematics achievement test possesses reasonable level of concurrent validity.

Problem Solving Ability Test (PSA) is developed by Dubey (2011) [5]. This test is presented with 20 statement representing different problems and person needs to responds to them by selecting the right solution from given 4 alternatives. This test is for the secondary school students included both boys and girls. The age range was from 12 to 17 years. The split-half reliability co-efficient was found to be 0.78 and rational equivalence method was found to be 0.76. The validity of this scale was determined by finding correlation of scores with standardized test. With as view to ascertaining validity coefficient of the problem solving ability test along with the Tondon's group intelligence test is 0.68 and test of reasoning ability is 0.85.

Statistical techniques used

The data were analyzed using descriptive as well as inferential statistics. The Two-Way Analysis of Variance (ANOVA) with 3x2 factorial design was computed using SPSS

version 20 to study the main effects and interaction effects of the independent variables i.e. problem solving ability and gender on mathematics achievement of secondary school students. Levene's Test of Homogeneity of Variance was used to test the assumption of homogeneity of variance before applying Two-Way ANOVA. Wherever F-value was found significant, then t-test was employed for further exploration.

6. Data analysis and discussion

The main objective of the present study was to find out the main and interaction effects of problem solving ability and gender on achievement in mathematics of secondary school students, data was subjected to analysis of variance of (3x2) factorial study with a randomized group design. In this section the first independent variable i.e. problem solving ability coded as (C) was varied into three types – High problem solving ability (C₁), Average problem solving ability (C₂) and Low problem solving ability (C₃). The second independent variable i.e. gender coded as B was varied at two levels – Male (B₁) and Female (B₂). Means and SDs of different sub-samples have been presented in the Table 1 and Fig. 2. The summary of ANOVA (3x2) has also been presented in Table 2, which is analyzed in terms of main effects and interaction effects.

Table 1
Mean's and S.D's Sub Samples of 3x2 Design for Achievement in Mathematics of secondary school students with respect to Problem Solving Ability and Gender

Problem Solving Ability (PSA)	Gender (B)	N	Mean	S.D.
High Problem Solving Ability (C ₁)	Male (B ₁)	55	49.56	9.06
	Female (B ₂)	58	46.82	11.02
Average Problem Solving Ability (C ₂)	Male (B ₁)	100	39.54	6.95
	Female (B ₂)	81	35.33	8.82
Low Problem Solving Ability (C ₃)	Male (B ₁)	44	29.40	10.53
	Female (B ₂)	62	29.04	10.23

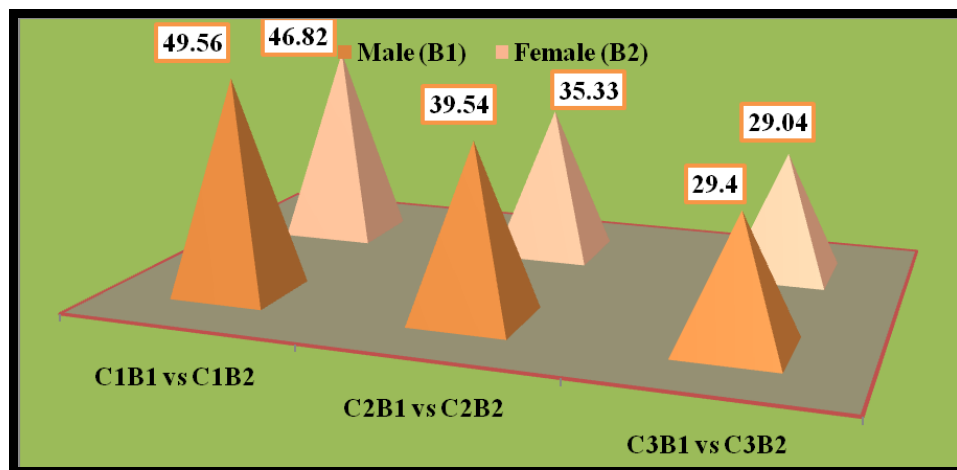


Fig. 2: Mean Scores of Sub Samples of 3x2 Design for Achievement in Mathematics of secondary school students with respect to Problem Solving Ability (PSA) and Gender

Table 2
Summary of Two way ANOVA (3x2 Factorial Design) For Achievement in Mathematics of secondary school students with respect to Problem Solving Ability (PSA) and Gender

Source of Variance	df	Sum of Squares (SS)	Mean sum of squares (MS)	F-ratios
Main Effects				
Problem Solving Ability (C)	2	19659.781	9829.890	115.445**
Gender (B)	1	552.030	552.030	6.483*

Problem Solving Ability x Gender	2	241.771	120.886	1.42(NS)
Double Interaction Effect				
Between Cells	5	20844.343
With in cells	394	33548.134	85.148
Total	399	54392.477

*significant at 0.05 level; **significant at 0.01 level; NS = Not Significant

❖ **Main Effects of Problem Solving Ability (PSA) and Gender on Achievement in Mathematics of secondary school students**

Problem Solving Ability (C)

It is cogent from the Table - 2 that F_C value of 115.44 with $df(2,394)$ is significant at 0.01 level for main effect of problem solving ability on achievement in mathematics. This means that problem solving ability has a significant independent effect upon achievement in mathematics. Therefore, the null hypothesis $H_{01}(a)$, "There exists no significant effect of

problem solving ability on achievement in mathematics of secondary school students **is not retained**. The present result is in tune with the results of Perveen (2010) [16]; Ifamuyiwa and Ajilogba (2012) [9] and Gupta, Pasrija and Kavita (2015) [8] who found that problem solving ability had a significant main effect on mathematics achievement. For further exploration, t-test was applied to find out the significance difference between mean scores of mathematics achievement of different groups for problem solving ability. The results have been shown in the Table-3

Table - 3
't'-values for the mean scores of Achievement in Mathematics of Secondary School Students with respect to Problem Solving Ability

Sr. No.	Groups	N		Mean		S.D.		t-values
1.	HPSA vs. APSA	113	181	48.15	37.65	10.16	8.10	9.78**
2.	APSA vs. LPSA	181	106	37.65	29.19	8.10	10.31	7.70**
3.	LPSA vs. HPSA	106	113	29.19	48.15	10.31	10.16	13.69**

** Significant at 0.01 level

HPSA: High Problem Solving Ability
LPSA: Low Problem Solving Ability

APSA: Average Problem Solving Ability

Table - 3 presents a comparative description of mathematics achievement of secondary school students on the basis of problem solving ability. It discloses that t-value (9.78) for students belonging high problem solving ability and students belonging average problem solving ability is found significant at 0.01 level. It may therefore, be inferred from the mean scores that students having high problem solving ability have significantly higher mathematics achievement (48.15) as compared to students having average problem solving ability (37.65). The same table exhibits that t-value (7.70) for students having average problem solving ability and students having low problem solving ability is found to be significant at 0.01 level.

Further, it is deduced from the mean scores for students belonging average problem solving ability is (37.65) higher than that of students having low problem solving ability. A glance at Table - 3 reveals that there is a significant difference in mathematics achievement between students belonging low problem solving ability and students having high problem solving ability. It can be further concluded that students having high problem solving ability have significantly higher mathematics achievement (48.15) than the students belonging low problem solving ability. The mean scores of main effect corresponding to problem solving ability on mathematics achievement have also been presented in the Fig.3

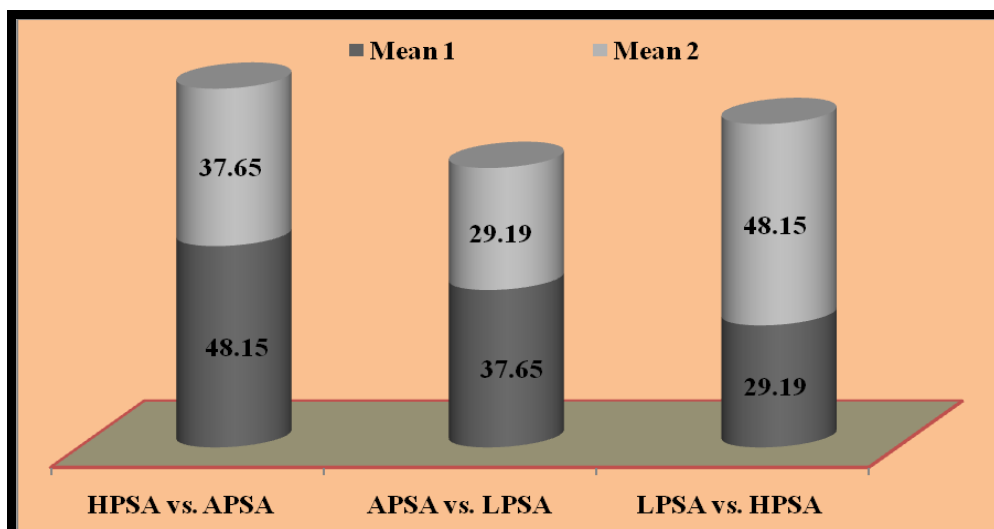


Fig. 3: Mean Scores for Main Effect of Problem Solving Ability on Achievement in Mathematics of secondary school students

Gender (B)

It is evident from Table 4.2(ii) that F_B value 6.48 with df (1,394) is highly significant at 0.05 level for the main effect of gender on achievement in mathematics. This means that gender has a significant independent effect upon achievement in mathematics of secondary school students. Therefore the null hypothesis H_{01} (b), "There exists no significant effect of gender on mathematics achievement of secondary school students" is **not retained**. This present finding is in line with

the findings of Awofala (2011) [2] who reported that gender has a significant effect on achievement in mathematics. However, this finding is in contrast with the finding of Ajai and Imoko (2015) [1] who reported that there was no significant difference between male and female secondary school students with respect to gender. In order to investigate further, the t-value was computed and has been given in Table 4

Table - 4
't'-value for the Mean Scores of Mathematics Achievement of secondary school students with respect to Gender

Groups	N	Mean	S.D.	't'- value
Male Students	199	40.07	11.00	2.90**
Female Students	201	36.71	12.09	

**Significant at 0.01 level

Table - 4 depicts that t-value (2.90) for the mean scores of achievement in mathematics between the male and female students is significant at 0.01 level. An analysis of the mean scores makes it clear that male students have (40.07) higher mathematics achievement than female students (36.71). The boys are performing better than girls. This may be attributed due to the fact that male students have favorable attitude towards mathematics than female students. The present

finding is in accordance with the findings of Khatoon (1988) [10] who reported that male students have higher mathematics achievement than female students. Whereas findings of Kumar and Karimi (2010) [11] who observed that female students have higher mathematics achievement than male counterparts. The mean scores of main effect corresponding to gender on achievement in mathematics have been depicted in fig.4

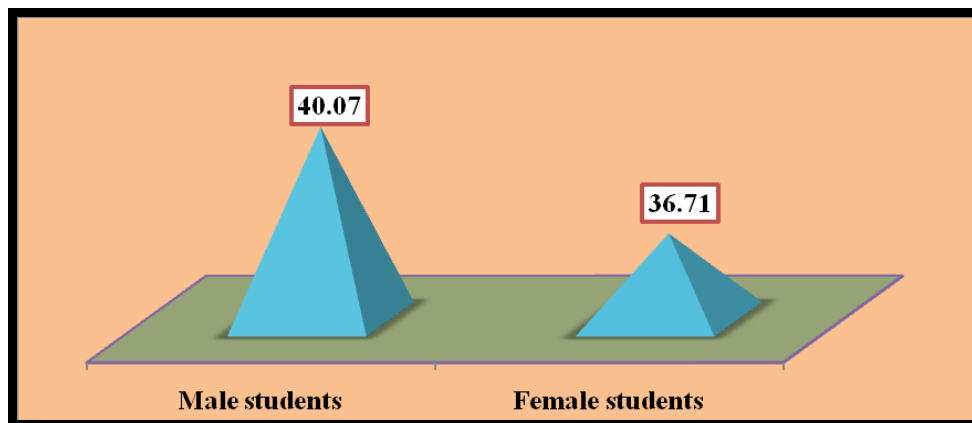


Fig. 4: Mean Scores for Main Effect of Gender on Achievement in Mathematics of secondary school students.

❖ Interaction Effect of Problem Solving Ability (PSA) and Gender on Achievement in Mathematics of secondary school students

Problem Solving Ability (C) x Gender (B)

It is apparent from the Table -2 that F_{CB} value for double interaction between problem solving ability and gender is 1.42 with df (2,394) which is insignificant at 0.01 level leading to the inference that problem solving ability and gender do not interact with each other. Therefore, the null hypothesis H_{02} "There exists no significant interaction effect of problem solving ability and gender on achievement in mathematics of secondary school students" is **retained**. It is inferred that there is no significant interaction effect of problem solving ability and gender on mathematics achievement of secondary school students. This finding is in contrast with the finding of Gupta, Pasrija and Kavita (2015) [8] who explored that there was no significant interaction effect of problem solving ability and gender on academic achievement.

7. Findings of the Study

- ❖ The study revealed that problem solving ability had a significant effect on mean achievement scores of secondary school students. A significant difference was found in mathematics achievement among high, average and low problem solving ability school students. It further revealed that students with high problem solving ability also exhibited higher mathematics achievement than average problem solving ability students and low problem solving ability.
- ❖ Gender was reported to have a significant effect in mean achievement scores of secondary school students. After comparing the mean achievement scores of boys and girls with the help of t-test, significant difference was found between the mathematics achievement scores of boys and girls leading to the conclusion that male students

performed higher mathematics achievement as compare to female students of secondary schools.

- ❖ No significant interaction effect of problem solving ability and gender on mathematics achievement scores of secondary school students was found.

8. Educational Implications

The finding of the present study indicates that there exist significant differences between the mathematics achievement of secondary school students on the basis of problem solving abilities. Thus, efforts should be made to help them to improve the problem solving ability which will help them in improving the mathematics achievement of the secondary school students. It was found that female secondary school students are having low mathematics achievement than their counterparts. So, proper guidance and counseling services pertaining to how to

get better problem solving abilities should be provided to them. Problem solving ability can be developed in students to help them effectively deal with problems that they faced daily. The ability involves critical thinking skills, analytical skills, creative thinking ability and logical reasoning of the student towards a problem that is presented in current situation or within their daily life. Developing problem solving ability enhances the student's ability to approach problems systematically and tackle the problems effectively. Mathematical problem solving approach allows students to broaden their thinking and enhances their perspectives in looking at problems. Moreover, workshops and seminars should be organized in all educational institutions to guide the students about the various techniques of making good problem solving abilities. Teacher should use the appropriate classroom techniques, methods and tools so that better problem solving ability can be accomplished.

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