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Impact of gender, family and school on problem-solving ability and mathematics achievement

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ABSTRACT

This study examines the problem-solving ability and mathematics achievement of secondary school students. It explores how these variables relate to gender, type of family, school type, and locality of school. Using a descriptive correlational method, the study sampled 1,200 students from Manipur, India. The investigators employed two tools they developed- the problem-solving ability test in mathematics and the mathematics achievement test (MAT) to gather data. The findings reveal that most students exhibit average problem-solving ability and mathematics achievement levels, irrespective of gender, type of family or locality of school. However, school type significantly impacts performance, with 39% of private school students achieving average mathematics achievement scores, compared to 43% of government school students scoring below average. A moderate positive correlation was identified between problem-solving ability and mathematics achievement across all demographic groups. These results underscore problem-solving ability as a critical determinant of success in mathematics, with implications for educators and policymakers. The study highlights the need for interventions focused on enhancing students' problem-solving ability to improve overall mathematics performance. Future research should explore additional variables and broader regional contexts to deepen understanding and inform targeted strategies. By addressing these dynamics, this study contributes to the development of more equitable and effective educational practices.

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1. INTRODUCTION

Mathematics is an exciting subject with real-world applications. Everybody, irrespective of their sex, gender, religion, color, ethnicity, and social class, uses mathematics from early in the morning through late at night. Mathematics can sometimes be considered a sense [1]. Hence, persons ignorant of mathematics can be compared to those who have lost one of the important senses and may be deprived of certain opportunities in life.

Everyone encounters problems in their lives. The nature of these problems may be biological, economic, educational, environmental, financial, health, physical, psychological, and spiritual. The main objective of education is to prepare a child to adapt to today's challenging society filled with problems. Research by Popović *et al*. [2] stated that "problem solving, problem posing, and real-world mathematics are being impelled to inevitably become an integral part of compulsory mathematical education due to the needs of modern society". Study by Chirimbana *et al*. [3] has also uncovered that learner with poor

problem-solving skills experience difficulties in solving mathematical problems and daily life, while other [4] indicated that problem-based learning potentially impacts learners' problem-solving abilities. Problem-based learning has become a widely adopted teaching approach across various academic disciplines. It is commonly integrated into undergraduate and postgraduate programs, including medicine [5], [6], social work education [7]. Beyond higher education, problem-based learning has also been successfully implemented at the elementary and secondary school levels [8]–[11], helping students develop critical thinking and problem-solving skills from an early age. So, inculcating problem-solving ability in students has become very important so that they can solve the problems they might encounter later in their lives.

Studying the correlation between problem-solving ability and mathematics achievement is important because these skills are deeply connected and can shape a student's overall academic and life success. Problem-solving is not just a mathematical skill it is a life skill. When students develop strong problem-solving abilities, they are better equipped to handle challenges, think critically, and make decisions in real-world situations. Research has consistently shown that students with strong problem-solving skills tend to achieve better learning outcomes [12]–[16]. This approach has been particularly effective in improving mathematics learning outcomes, highlighting its impact on students' overall understanding and performance in the subject [17].

Gender differences in education are shaped by societal norms and expectations, influencing how boys and girls engage in mathematics learning and problem-solving. Exploring these differences can highlight gaps and guide strategies to support both genders, fostering equal opportunities in education. Family structure also plays a key role in a child's learning experience, affecting access to resources, emotional support, and parental involvement. By understanding these dynamics, educators can create targeted interventions for students from various family backgrounds. The type of school a child attends impacts their mathematics learning and problem-solving ability due to differences in resources, teaching quality, and support systems. Examining these factors can uncover disparities and guide efforts to ensure all students receive a quality education. Geographical location further shapes educational opportunities. Urban schools often have more resources, while rural schools may struggle with limited access to technology and qualified teachers. Studying how locality influences mathematics learning and problem-solving abilities is crucial for addressing inequalities and helping every student thrive, regardless of where they live.

This study focuses on understanding the relationship between problem-solving ability and mathematics achievement, particularly in the context of secondary school students in Manipur, India. Understanding the relationship between problem-solving ability and mathematics achievement can help educators identify gaps in learning and create strategies to support students who struggle. It also sheds light on how factors like gender, family type, school type, and locality of school influence these abilities, allowing for more tailored teaching approaches. Improving problem-solving abilities can ultimately lead to better mathematics performance and greater confidence in tackling academic and everyday challenges. This insight is key to preparing students for future success, not just in school but in life. By examining the influence of gender, type of family, type of school and locality of school, this study aims to provide insights that could inform educational practices and policies designed to improve mathematics education.

Various studies [18]–[20] have reported that the students' level of problem-solving ability was low, while some studies [21], [22] reported an average level of problem-solving ability of the students. In contrast, Kurnaz [23] found that the students' level of problem-solving ability was above average. Again, a study by Amalina and Vidákovich [24] reported that the students' level of mathematics achievement was average. Previous studies [25]–[31] have also reported positive correlations between problem-solving ability and mathematics achievement among secondary school students. However, it is noteworthy that study by Philippou and Christou [32] found a negative correlation between problem-solving ability and mathematics achievement, contrasting with the general trend.

Existing studies did not sufficiently explore the correlates influencing students' problem-solving ability and mathematics achievement, leaving a gap in understanding the interplay of various factors affecting these outcomes. Notably, there was a lack of research examining the impact of the type of family on these abilities, and few studies specifically targeted secondary school students, highlighting the need for further investigation. Furthermore, the assessment tools used in prior studies for measuring problem-solving ability were either based on strategies or dimensions, failing to integrate both aspects comprehensively. Similarly, previous mathematics achievement tests (MATs) were outdated due to curriculum changes following the COVID-19 pandemic. To address these limitations, this study employed a newly developed problem-solving ability test incorporating both dimensions and strategies, along with a MAT aligned with the latest curriculum.

While similar studies have been conducted across various Indian states and union territories, research on problem-solving ability and mathematics achievement remains scarce in the North Eastern States, particularly in Manipur. This regional gap underscores the need for localized studies to better understand the unique factors influencing students' learning outcomes. Motivated by this gap, the present study moves

beyond isolated factors by examining the interplay of gender, family, and school in shaping students' problem-solving ability and mathematics achievement. Unlike previous research that treats these variables independently, this study integrates multiple influencing factors into a holistic framework, providing a comprehensive understanding of their combined impact.

Additionally, by emphasizing real-world thinking over mere scores, this study offers valuable insights for improving learning environments and promoting equity in mathematics education. The findings contribute both theoretically and practically, helping educators and policymakers develop more effective, evidence-based strategies for enhancing student learning. The objectives of the present study are: i) to examine the level of problem-solving ability and mathematics achievement of students in relation to gender, type of family, type of school, locality of school and entire sample; and ii) to examine the correlation between problem-solving ability and mathematics achievement of students in relation to gender, type of family, type of school, locality of school and entire sample.

2. METHOD

2.1. Population and sample

A descriptive-normative survey, which is correlational as well as cross-sectional in nature, was adopted in the study. The population consisted of classes 9 and 10 students from schools affiliated to the Board of Secondary Education Manipur (BSEM) in the Thoubal District, Manipur, India. The stratified random sampling technique was used to collect a sample of 1,200 students. Stratification is done to ensure that the sample is representative of key subgroups within the population, making the findings more generalizable and reliable. Gender (male/female), type of family (nuclear/joint), type of school (private/government), and locality of school (urban/rural) of the students form the different strata and the variables of the study. The distribution of the students into different strata is given in Figure 1.

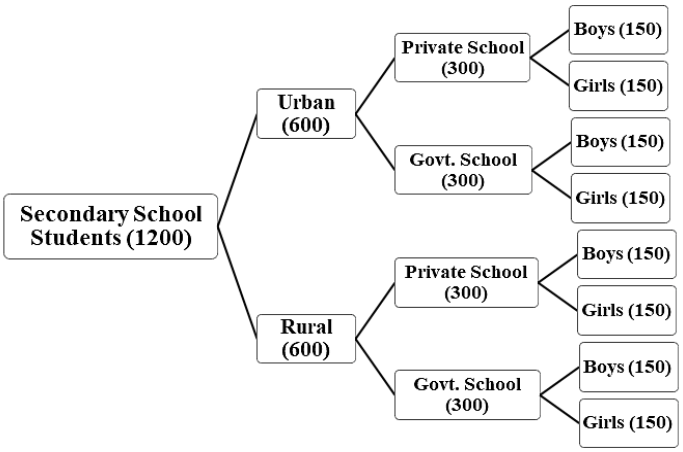

Figure 1. Distribution of students in the sample

2.2. Tools for data collection

The problem-solving ability test in mathematics (PSATM) and the MAT constructed by the investigators were used to collect the data for the test. The PSATM is constructed based on five dimensions (visualization, manipulation, association, reasoning and numerical ability) and ten strategies: i) draw a picture or diagram; ii) use coordinates; iii) use a variable; iv) solve an equation; v) look for a pattern; vi) make a list; vii) use direct reasoning; viii) work backwards; ix) use properties of numbers; and x) look for a formula, of problem-solving ability. The MAT is constructed based on five main branches of school mathematics (arithmetic, algebra, geometry, mensuration and statistics) and four educational objectives of cognitive and psychomotor domains (knowledge, understanding, application and skills). The PSATM and MAT comprised 25 and 40 multiple-choice items with four alternatives, respectively. Among the four alternatives, only one is correct (key), and the remaining three are incorrect (distractors). One mark is awarded for every correct response, while zero is given for an incorrect response. The duration of the PSATM and MAT are 50 minutes and 60 minutes, respectively. The reliabilities of both tests were assessed through the odd-even split-half and test-retest methods. Both tests have high-reliability measures in both methods, ranging from 0.71 to 0.94.

2.3. Data collection and statistical tools

The aims of the tests were discussed in detail with the principals and authorities of the schools, and the students were informed of them. The students were briefed on how to answer the questions, and they were promised that their replies would be kept confidential and utilized for research purposes only. To confirm the suitability for parametric tests, the normality of the data was evaluated by examining skewness and kurtosis values. The PSATM and MAT scores showed skewness values of 0.527 and 0.654, respectively, and kurtosis values of 0.299 and 0.132, respectively, within the acceptable range of -2 to +2, indicating that the data followed a normal distribution [33]. Suitable statistical techniques like mean, Pearson correlation, and standard deviation were used to analyze the data collected.

3. RESULTS AND DISCUSSION

3.1. Regarding the first objective

Table 1 shows that out of the 1,200 students, 22 (1.83%), 389 (32.41%), 540 (45%), 178 (14.83%) and 71 (5.92%) students, respectively have low, below average, average, above average and high level of problem-solving ability. The majority of male (45.5%) and female (44.5%) students have average problem-solving ability. The majority of students from both nuclear (46.73%) and joint (41.63%) families have an average level of problem-solving ability. The majority of students from both urban (48.5%) and rural (41.5%) schools have an average level of problem-solving ability. The majority of students from both private (44.67%) and government (45.33%) schools have an average level of problem-solving ability.

Table 2 shows that out of the 1,200 students, 13 (1.08%), 391 (32.58%), 474 (39.5%), 243 (20.25%) and 79 (6.58%) students, respectively have low, below average, average, above average and high level of mathematics achievement. The majority of both male (39.17%) and female (39.83%) students have an average level of mathematics achievement. The majority of students from both nuclear (40.93%) and joint (36.70%) families have an average level of mathematics achievement. The majority of students from both urban (41.67%) and rural (37.33%) schools have an average level of mathematics achievement. The majority of students from private schools (39%) have an average level, and government schools (43%) have a below-average level of mathematics achievement.

Table 1. Percentage-wise distribution of students according to their level of problem-solving ability

Level →		E (0-7)		D (8-11)		C (12-15)		B (16-18)		A (19-25)	
Variable ↓		N	%	N	%	N	%	N	%	N	%
Entire sample		22	1.83	389	32.41	540	45	178	14.83	71	5.92
Gender	Male	13	2.17	173	29.33	273	45.5	100	16.67	41	6.83
	Female	9	1.5	216	36	267	44.5	78	13	30	5
Type of family	Nuclear	15	1.89	264	33.25	371	46.73	97	12.22	47	5.92
	Joint	7	1.72	125	30.79	169	41.63	81	19.95	24	5.91
Locality of school	Urban	6	1	143	23.83	291	48.5	116	19.33	44	7.33
	Rural	16	2.67	246	41	249	41.5	62	10.33	27	4.5
Type of school	Private	5	0.83	143	23.83	268	44.67	119	19.83	65	10.83
	Govt.	17	2.83	246	41	272	45.33	59	9.83	6	1

Note: E=low, D=below average, C=average, B=above average, A=high, and N=number of students at a particular level.

Table 2. Percentage-wise distribution of students according to their level of mathematics achievement

Level →		E (0-11)		D (12-18)		C (19-24)		B (25-31)		A (32-40)	
Variable ↓		N	%	N	%	N	%	N	%	N	%
Entire sample		13	1.08	391	32.58	474	39.5	243	20.25	79	6.58
Gender	Male	5	0.83	168	28	235	39.17	140	23.33	52	8.67
	Female	8	1.33	223	37.17	239	39.83	103	17.17	27	4.5
Type of family	Nuclear	9	1.13	252	31.74	325	40.93	157	19.77	51	6.42
	Joint	4	0.99	139	34.24	149	36.70	86	21.18	28	6.90
Locality of school	Urban	7	1.17	169	28.17	250	41.67	130	21.67	44	7.33
	Rural	6	1	222	37	224	37.33	113	18.83	35	5.83
Type of school	Private	0	0	133	22.17	234	39	170	28.33	63	10.5
	Govt.	13	2.17	258	43	240	40	73	12.17	16	2.67

Note: E=low, D=below average, C=average, B=above average, A=high, and N=number of students at a particular level.

3.2. Regarding the second objective

Figure 2 shows the scatter plot of the students' problem-solving ability and mathematics achievement scores. The correlation coefficients (Pearson) between PSATM and MAT scores of the students in relation to gender (male-female), type of family (nuclear-joint), type of school (private-government),

locality of school (urban-rural) and the entire sample are found to be ranging between 0.40 and 0.61 as shown in Table 3, indicating moderate positive correlations. The p-values were also found to be 0.000, indicating significant correlations at a 0.01 level of significance (two-tailed). Thus, there were moderately positive significant correlations between problem-solving ability and mathematics achievement of the students in relation to gender, type of family, type of school, locality of school and the entire sample. Figure 2 also clearly confirms the results.

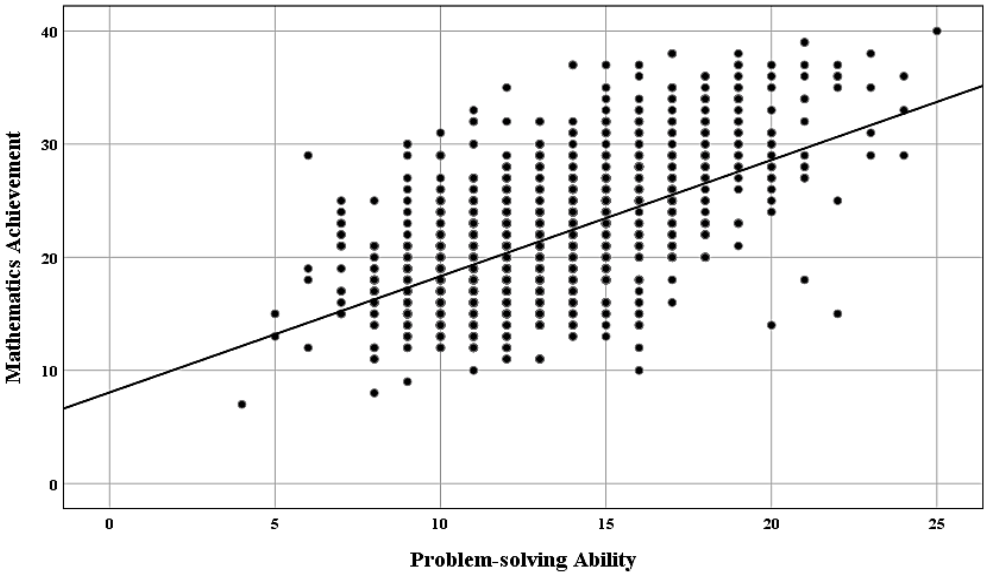

Figure 2. Scatter plot of the sample's PSATM and MAT scores

Table 3. Correlation between mean PSATM scores and mean MAT scores of students

Variables	Sub-variables	N	Mean PSATM	Mean MAT	p-value	Correlation	Remarks
Gender	Male	600	13.38	22.33	0.000	0.593	Significant
	Female	600	12.80	20.67	0.000	0.552	Significant
Family type	Nuclear	794	12.98	21.47	0.000	0.596	Significant
	Joint	406	13.29	21.56	0.000	0.550	Significant
Type of school	Private	600	14.05	23.43	0.000	0.591	Significant
	Govt.	600	12.13	19.57	0.000	0.440	Significant
Locality of school	Urban	600	13.71	21.98	0.000	0.604	Significant
	Rural	600	12.47	21.02	0.000	0.546	Significant
Entire sample		1200	13.09	21.50	0.000	0.579	Significant

3.3. Discussion

The present study found that the majority of students, 45% (540), have an average level of problem-solving ability, which is consistent with the results of various studies [21]–[22]. However, it contradicts the results of many studies [18]–[20], [23]. Again, the present study found that the majority of students, 39.5% (474), have an average level of mathematics achievement. This result is consistent with the results of previous studies [24].

The lack of proper teaching resources, insufficiently trained teachers, and low teacher motivation also play a role. The impact of the COVID-19 pandemic and fear or anxiety related to mathematics further impede students' performance. Moreover, the emphasis on rote learning rather than fostering a deep understanding of mathematical concepts has likely limited students' ability to develop critical thinking and effective problem-solving abilities. The disconnect between what is taught in the classroom and the students' everyday experiences may have made the subject less engaging and harder to relate to, contributing to the average performance. Additionally, the ongoing fear or anxiety surrounding mathematics, often referred to as "math anxiety," could further inhibit students' confidence and willingness to engage with the subject, thereby impacting their overall achievement and problem-solving abilities. These combined factors seem to have created an environment where students struggle to excel beyond an average level in problem-solving ability and mathematics.

The correlation coefficients between PSATM and MAT scores of the students in relation to gender, type of family, type of school, locality of school and the entire sample were found to range between 0.40 and 0.61, indicating moderately positive significant correlations. These findings are consistent with the results of various previous studies [25]–[31]. However, there are studies [32] that have found contradictory results.

Problem-solving stimulates cognitive development in critical areas like pattern recognition and logical reasoning, which are essential for mathematical thinking. It also challenges students to apply their mathematical knowledge in real-world contexts, thereby deepening their understanding and retention of concepts. Furthermore, problem-solving enhances students' ability to contextualize problems and often involves collaborative learning, which fosters communication and teamwork. These experiences not only improve mathematical skills but also cultivate intrinsic motivation, encouraging students to engage more deeply with mathematics and achieve higher levels of success.

4. CONCLUSION

The findings of this study highlight the importance of problem-solving ability as a significant factor influencing mathematics achievement among secondary school students. The moderate positive correlations observed across various demographic and educational variables suggest that strategies aimed at improving students' problem-solving ability could lead to better mathematics achievement. These results have important implications for educators and policymakers, emphasizing the need for targeted interventions that enhance problem-solving ability in students. Future research could expand on these findings by exploring additional variables and conducting comparative studies across different regions or educational systems.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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Jocyline Thokchom			✓			✓	✓	✓		✓				✓

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [LNS], upon reasonable request.

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