

Factors Affecting Algebraic Problem-solving Skills of Secondary School Students

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ABSTRACT The study is done to investigate the proficiency level of students' basic skills (BS) and attitude towards algebra (ATA) and their relation with algebraic problem-solving skills (PSS). Basic Skills Test (BST) and Problem Solving Test (PST) are done to know proficiency level of BS and PSS, and the Algebraic Attitude Scale (AAS) is designed to know the ATA. The reliability analysis of the questionnaire is 0.842 measured by Cronbach alpha. The proficiency level of students' BS and level of attitude is determined by using frequency, percentage distribution, mean and weighted mean. To determine the relationship between PSS and the factors (ATA and BS), Chi-square test is used. The result shows that students' PSS are significantly related to their level of ATA and BS.

INTRODUCTION

Mathematics is one of the compulsory subjects taught at the elementary and secondary levels in India. It has an important role in developing scientific, technological and in almost all fields of study. It is a fundamental subject of the education system at the national and international level. But Mathematics is treated as one of the difficult subjects in the schooling system. Secondary stage Mathematics comprises of different topical arrangements such as arithmetic, algebra, geometry, statistic, trigonometry and probability and all of these are interconnected. Algebra is an integral part of the mathematics curriculum in upper primary and secondary schools. It is a branch of mathematics that uses letters, symbols, and numbers to solve problems (Usman and Musa 2015). In daily life, algebra is necessary in understanding and acquiring mathematical problem-solving skills (PSS), reasoning, communication and critical thinking. So algebra is the language of mathematics through which most of the mathematical situations can be communicated (Iji et al. 2015). In order to cope up with the algebraic knowledge, other disciplines like mathematical abstraction and modeling are required. Most of the secondary level students struggle to understand mathematics due to a lack of basic knowledge about algebra, for which they are obliged to discontinue their studies of higher level mathematics (Greens and

Rubenstein 2008). Hence, algebraic proper knowledge and skills is the pivotal base for the development of the higher level of thinking and PSS. Critical thinking of students has significant positive effect on problem-solving (Baradaran et al. 2021) and problem-solving ability (PSA) has a significant effect on academic achievement (Gupta et al. 2015). So, to extent the success rate of students in mathematics, it is essential to develop their PSS (Moneva et al. 2020, Saygili 2017). Mathematical PSS are the key objectives of teaching-learning mathematics. So, in order to enhance the PSS is a main goal of mathematics learning, as problems are rooted in daily life (Patton et al. 1997).

Problem-solving is a major issue and it's a prominent research area in mathematics education. One of its noted objectives is to recognize the factors that affect in problem-solving. Many secondary school students face difficulties in learning algebra (Brian 2010; Anthony et al. 2012). As a result of their difficulties in solving problems, students develop a negative attitude towards learning algebra (Anthony et al. 2012). Several studies have found that there are various factors that affect PSS (Schoenfeld 2007; Dendane and Math 2009; Pimta et al. 2009). The associating factors with it are concentration of the learner, behavior of the teacher, attitudes toward mathematics (ATM), basic knowledge, concepts and facts, metacognition, peer learning, BS and so on. According to Yunus et al. (2021),

achievement motivation, metacognitive awareness, and students' attitudes toward learning are all positively related to PSA.

Many studies have found that learners' attitudes towards problem-solving (ATPS) in algebra are strongly associated with their ATPS in daily life (Effandi and Normah 2009; Tezer and Karasel 2010; Lai et al. 2015; Bala and Shaafiu 2016). ATM plays a vital role in the teaching-learning of mathematics, and it affects students' achievement in mathematics (Tella 2007; Farooq and Shah 2008). Adeaga and Veronica (2019) exposed that there is an association of students' ATM, skills and performance.

Effandi and Normah (2009) recommended that students' negative attitude should be overcome to get rid of the poor PSS in their later life. It is further supported that students should have a positive ATPS to achieve success in their life (O'Connell 2000). Students' ATM had a significant positive effect on PSA (Baradaran et al. 2021). Inferential analysis of Bakar et al. (2020) established that there is a significant positive relation between overall ATM with problem-solving achievement.

In a study, Silao (2018) pointed out that student's PSS in mathematics are significantly associated with their BS, ATM and parental involvement. He also found that students' performance in PSS and BS is average and a fair ATM. Cañete (2002) found in his study that students with acceptable performance in BS and a fair ATM had low achievement in PSS.

By thorough studies many scholars have unraveled the students' ATPS in algebra. According to Tolar (2008), the students with poor proficiency levels in algebra have trouble while solving algebraic problems and this is one of the reasons of hindering access to educational and future opportunities. In the year 2012 and 2013, a study report in the Maldives established that performance in algebra was worse than in any other mathematical discipline (UNICEF and NIE 2014) which shows that students lack in algebraic knowledge; it was thought to be students' poor ATPS in algebra. Moreover, it becomes conspicuous from the findings of many researchers that the poor performance of the Nigerian students in mathematics is their negative ATPS in algebra (Adeleke 2007; Banerjee and Subramaniam 2012; James and Adewale 2012).

Gallo and Johnson (2008), wanted to know the basic math skills of the students by conduct-

ing a test among various college students. Consequently, they found that they had no mastery in math basic skills and mastery of very elementary math skill which is very essential in the applied context. So they recommended teachers that they should find out the poor students in this regard in order to give special treatment to remove the problem.

In India, very few researches have been done in the field of problem-solving. PSA in mathematics of class IX standard students were surveyed by Senthamarai et al. (2016) and in they reported that students' PSA is average.

Anwar (2015) made a study to find the relationship between PSA and ATM. He found that there was a marginal relationship between PSA of class IX students' and their ATM. He also mentioned that there is no influence of high or low attitude on PSA.

Vijayan (2014) found that students higher ATM provides higher achievement in mathematics. He also conceived that student's mathematical attitude is significantly correlated with their mathematical base. His findings indicate that if the student's mathematical base is poor then their performance in mathematics is likely to be weak. He further pinpointed that their performance can be developed by developing their ATM, study habits and parental involvement.

In Assam, several researchers (Das and Das 2013; Das et al. 2015; Sarma and Ahmed 2013) have found that the ATM plays a central role in problem-solving. In another study Ali et al. (2014) found that students' basic knowledge affects their performance and they require a strong foundation of BS.

Though there are many studies have been done on problem solving in algebra at the international level, very few studies has been done at the national and regional levels. So, it is imperative to think about PSS in algebra and its affecting factors like BS and ATA in regional level.

Objectives

1. To investigate the proficiency level of students' BS in algebra.
2. To investigate the proficiency level of students' ATA.
3. To investigate the proficiency level of PSS in algebra.

4. To investigate the relationship between the proficiency level of students' BS and PSS in algebra.
5. To investigate the relationship between the proficiency level of students' ATA and PSS in algebra.

Hypothesis

H_0^1 : There is no significant relationship between the level of students' BS and PSS in algebra.

H_0^2 : There is no significant relationship between the level of students' ATA and PSS in algebra.

Definition of Terms Used

Attitude: It is used to mean students' interest in algebra likes or dislikes. The attitude of a student was measured by the Algebraic Attitude Scale (AAS).

Basic Skills (BS): It refers to the students' ability to use the four fundamental operations in algebra, formation of algebraic expression, linear and quadratic equation. In this paper students' proficiency level of BS of algebra are measured with the Basic Skill Test (BST).

Problem-Solving Skills (PSS): PSS is the way used to find a solution to an algebraic question. It includes measuring the unknowns (variables) in word problems, polynomials, linear and quadratic equations etc. In this paper, students' proficiency level of PSS of algebra is measured with the Problem-Solving Test (PST).

METHODOLOGY

The descriptive survey method is adopted to carry out the study. The study is done in the Morigaon district of Assam, India.

Respondent

For the study, secondary school students are taken as respondent. For that purpose 200 secondary school students of class IX are taken as the sample.

Research Instrument

For collecting data, the following three instruments are used: BST, PST and AAS. The BST and

PST are done to know the proficiency level of BS and PSS; and the AAS has been designed to know the ATA.

To know the relations between BS and PSS, two tests are done based on algebraic BS and PSS which consist of 20 questions having four alternative options for each question. Out of those four options, only one option is correct. For the correct option 1 mark is given, and for the wrong option, 0 marks are given. Finally, all the marks are added.

For AAS the researchers have developed a questionnaire with the help of a research expert relating to the field. The Likert five point scales that are "Strongly Agree (SA)", "Agree (A)", "Neutral (N)", "Disagree (DA)", or "Strongly Disagree (SD)" are used in this questionnaire. The questionnaire consists of 20 items. The Reliability analysis of the questionnaire is 0.842 measured by Cronbach alpha.

Statistical Tools

The following statistical treatments are used to analyze and sum up the data.

The proficiency level of students' BS and level of ATA is determined by using frequency, percentage distribution, mean and weighted mean.

For the mean score of BST and PST are described by the five category Scale, that is, Poor- (0 to 29%); Below Average- (30% to 44%); Average - (45% to 59%); Good - (60% to 79%); Excellence - (80% to 100%).

Students mean score in AAS are described as follows-Each positive items from 1 to 15 numerical scores are considered as 5 –SA= Highly Positive, 4 –A= Positive, 3 –N=Fair, 2 –DA=Negative, and 1 –SD =Highly Negative. Also for negative items that is, items from 16 to 20 the scores have been reversed.

Statistical Techniques

The Chi-square (χ^2) test is used to determine whether there is a significant relationship between PSS and the following factors: BS proficiency level and ATA.

RESULTS

From Table 1, it is found that among the 200 students only nine (4.5%) students have a mean score 17.9 out of the 20 items given in the BST.

The percentage of correct responses is 88.35 and their proficiency level of BS is Excellence. Forty-eight (24%) students are found in the Good category whose mean and percentage of correct responses are 13.98 and 69.9. Maximum 79 (39.5%) number of students' proficiency levels is Average. Their mean and percentage of correct responses are 10.38 and 51.9, as shown in Table 1. The proficiency level of 50 (25%) students is Below Average, their mean response is 6.93 and the percentage of correct response is 34.65. Also, 14(7%) number of students are found in the Poor category level. The mean score of these students is 3.43 and the percentage of correct responses was 17.2 or they answered 17.2 percent correctly. It is also seen from Table 1, the average weighted mean score of the BST is 10.23, which is equivalent to 51.15 percent and their proficiency level of BS is found to be Average.

From Table 2, it is found that among the 200 students 25 (12.5%) have a Highly Positive ATA; 54 (27%) students have a Positive ATA; 98 (49%) have a Fair ATA; 23 (11.5%) have a Negative ATA; and no student has a Highly Negative ATA. The average weighted mean score of students' ATA is 3.39, which is 67.8 percent and the level of ATA is Fair. Also, it is indicated that majority of students' ATA is Fair as the highest 49 percent of students have a Fair ATA.

From Table 3, it is found that among the 200 students, only 6 (3%) students have a mean score 17.5 out of the 20 items given in the PST. The percentage of correct responses or correctly answered is 87.5percent in the test and their proficiency level of PSS is Excellence. At the Good proficiency level there are 43 (21.5%) students whose mean score is 13.84 and they answered 69.2 percent correctly. The proficiency

Table 1: Profile of students' BS

<i>Basic skills</i>	<i>No. of students</i>	<i>% of students</i>	<i>Mean score</i>	<i>Weighted mean</i>	<i>%</i>	<i>Proficiency level</i>
Excellence	9	4.5	17.9	161.1	88.35	Excellence
Good	48	24	13.98	671.04	69.9	Good
Average	79	39.5	10.38	820.02	51.9	Average
Below average	50	25	6.93	346.5	34.65	Below average
Poor	14	7	3.43	48.02	17.2	Poor
Total/ Average	200	100%	10.52	10.23	51.15%	Average

Table 2: Profile of students' ATA

<i>ATA</i>	<i>No. of students</i>	<i>% of students</i>	<i>Mean score</i>	<i>Weighted mean</i>	<i>%</i>	<i>ATA level</i>
Highly positive	25	12.5	4.28	107	85.6	Highly positive
Positive	54	27	3.78	204.12	75.6	Positive
Fair	98	49	3.21	314.58	64.2	Fair
Negative	23	11.5	2.31	53.13	46.2	Negative
Highly negative	0	0	0	0	0	Highly negative
Total/ Average	200	100%	13.58	3.39	67.8%	Fair

Table 3: Profile of students' PSS

<i>Problem solving skills</i>	<i>No. of students</i>	<i>% of students</i>	<i>Mean score</i>	<i>Weighted mean</i>	<i>%</i>	<i>Proficiency level</i>
Excellence	6	3	17.5	105	87.5	Excellence
Good	43	21.5	13.84	595.12	69.2	Good
Average	65	32.5	9.96	647.4	49.8	Average
Below average	70	35	6.88	481.60	34.4	Below average
Poor	16	8	3.37	54	16.85	Poor
Total/ Average	200	100%	10.31	9.42	47.1%	Average

level of 65 (32.5%) students is Average with a mean score of 9.96 and 49.8 percent correct responses. Maximum 70 (35%) number of students' proficiency level is Below Average. Their mean score is 6.88 and the correct answered percentage is 34.4. Also, there are 16 (8%) number of students in the Poor category level. The mean score of these students is 3.37 and the percentage of correct responses is 16.85 or they answered 16.85 percent correctly. From Table 3, the average weighted mean score of PST is 9.42, which is equivalent to 47.1 in percent and their proficiency level of PSS is found to be Average.

In Table 4, the χ^2 computed value is 81.14 which is greater than the tabular value of 26.30 at 0.05 significant level and 16 degree of freedom (Df). Hence, the hypothesis H_0^1 is rejected. So there is a significant relationship between the students' BS and the PSS in algebra.

Table 4: Relationship between students' PSS and BS

Factor	Df	χ^2 computed	χ^2 tabular	Decision
Basic Skills	16	81.14	26.30	H_0^1 is rejected

Again from Table 5, the χ^2 computed value is 75.25 which is greater than the χ^2 tabular value at 0.05 significant level and 16 Df. Hence the hypothesis H_0^2 is also rejected and there is a significant relationship between the students' ATA and PSS in algebra.

Table 5: Relationship between students' PSS and ATA

Factor	Df	χ^2 computed	χ^2 tabular	Decision
Attitude	16	75.25	26.30	H_0^2 is rejected

DISCUSSION

The study is done to examine the proficiency level of students' ATA and BS towards algebra and their relation with algebraic PSS. The results of the study indicated that overall students' proficiency level of BS and PSS is Average (Senthamarai et al. 2016) and the number of student is in declining trend in higher level of performance. Though in both cases, students' proficiency level is same but there is difference in number of student and test mean score. Stu-

dents' average ATA is Fair and also the highest number of students' ATA is found in the Fair level. The numbers of student decrease from a Fair level of ATA to a Highly Positive level. It is also observed that number of student in the higher proficiency level of PSS decreases as compared to their BS and ATA levels. These findings are supported by Cañete (2002), pupils had a decent BST score and a fair ATM, but a low PST score.

Finding reveals that there is a significant relation between BS and PSS. Students' higher proficiency level of BS increases higher level of achievement in PSS and poor proficiency level causes lower achievement in PSS (Vijayan 2014). So, that student needs a strong foundation of BS to succeed in PSS (Pambudi et al. 2020).

The result also reveals that there is a significant relationship between ATA and PSS. Students' highly positive attitude develops problem-solving achievement. In many studies researchers have found that there is a positive correlation between attitude and problem-solving (Bakar et al. 2020; Baradaran et al. 2021; Kusuma et al. 2021; Vijayan 2014).

These results are also consistent with the findings of Silao (2018), who reveals that students' PSS are related to their BS and attitude.

CONCLUSION

Problem-solving is an important skill of students' better achievement of mathematics and future opportunities. From the study it is shown that students' PSS is significantly related to their level of ATA and BS. So it can be concluded that students' better level of BS and ATA have an influence on their PSS and their achievement.

RECOMMENDATIONS

From the study it is found that students' PSS are significantly related to their level of ATA and BS. The results and the paper can encourage the researchers to pay more attention on more factors other than the factors mentioned in this paper which can be helpful to enhance the PSS of students.

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