International Journal of Evaluation and Research in Education (IJERE)
Vol. 12, No. 2, June 2023, pp. 1016~1022
ISSN: 2252-8822, DOI: 10.11591/ijere.v12i2.23926

An investigation on the effects of attitude towards algebraic problem-solving achievement

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Article Info

Article history:

Received Feb 11, 2022
Revised Nov 24, 2022
Accepted Dec 30, 2022

Keywords:

Algebra
Gender
Perseverance
Self-confidence
Type of school
Willingness

ABSTRACT

The main focus of this work is to explore the effects of students' attitudes towards problem solving (ATPS) in algebra with respect to gender and type of school. The contribution of the predictor variables of ATPS in algebra to the prediction of problem-solving achievement (PSA) is being investigated. For the study, 200 class IX students are randomly selected from the government (GOVT) and private (PVT) schools in the Morrigan district, India. The algebraic attitude scale (AAS) is used to determine students' ATPS, whereas the problem-solving test (PST) is used to determine students' PSA in algebra. The AAS instrument consists of three subscales: perseverance (PE); self-confidence (SC), and willingness (WL). The t-test and multiple regression analysis are used to analyze the collected data. The finding reveals that there are statistically significant differences in students' ATPS based on gender and type of school. The finding also reveals that PE, SC, and WL have a significant positive relationship with the PSA in algebra. Therefore, it is suggested that teachers should make an effort to provide support in the form of explanations, modeling, coaching, and other forms of assistance, as well as a conducive environment that encourages students' overall ATPS that can enhance their PSA in Mathematics.

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1. INTRODUCTION

The German mathematician Carl Friedrich Gauss referred to Mathematics as "the Queen of the Sciences." Nowadays, all people know the importance of Mathematics. Modern Mathematics is composed of several branches. Algebra is an inseparable part of one of the main branches of Mathematics in the world. It is concerned with structures, relations, and quantity. Knowledge of algebra is introduced at the primary level where students are introduced to arithmetic operations and its knowledge is formally applied at the secondary level. Algebra is considered the gateway to the extension of difficult arithmetic articulations, as well as a step in the learning process from concrete to abstract concepts [1]. The study of algebra, as a discipline in Mathematics within middle and high school syllabuses, is generally different in different countries of the world. Some countries provide it as part of an integrated curriculum, whereas others may assign it as a unified topic, i.e., as a combination of algebra, arithmetic, and geometry within the mathematics curriculum. In the Indian school curriculum, algebra is featured as one of the core topics in mathematics. Proper learning of algebra enhances students' mathematical problem-solving skills, reasoning, communication, and critical thinking. Many scholars considered algebra as the language of Mathematics through which most mathematical situations can be communicated. It is important to learn algebra as a language as it helps us to understand Mathematics

in a systematic way [2]. Algebra serves as a gatekeeper to higher education and future opportunities [3]. Though algebra plays an important role in learning Mathematics, most secondary school students have difficulties in learning algebra. Students' difficulties in learning algebra are mostly related to problem solving [4]. The development of problem-solving skills in mathematical learning is one of the major recommendations for teaching Mathematics [5]. In a report of 7th-grade students in Turkey, it was revealed that students' problem-solving achievement (PSA) has a significant effect on their academic achievement [6].

The most important component in a student's academic achievement is their attitude. Research indicates that "attitude" is one of the most influential factors in achievement [7]. Several studies have been conducted in Mathematics education on the relationship between attitude toward Mathematics and achievement [7]–[10]. There is a significant relationship between attitudes toward Mathematics and achievement among high school students [11]. It was also exposed that attitudes toward Mathematics had a significant influence on university students' achievement [12]. In a study of Malaysian pre-university students, it was found that there was a significant positive relationship between overall attitudes toward Mathematics and mathematical PSA [13]. So students' achievement may be influenced by their attitude toward problem solving (ATPS) [14]. Students' attitudes toward mathematical problems are necessary to make sure outstanding academic achievement [15]. This attitude plays a major role in mathematical problem solving and its achievement.

Students' achievement may be influenced by ATPS. Several mathematical educational studies have been conducted in which students' attitudes and achievement has been extensively explored [16]. Duffy, Gunther, and Walters [17] mentioned that there is a relationship between attitudes toward Mathematics and PSA. Students' ATPS in algebra are highly associated with their overall ATPS [15]. According to Sunzuma, Masocha, and Zezekwa [18], "attitude towards problem solving of algebra may consist of enjoying, liking and having an interest in algebraic problems or the opposite." Students must have a positive ATPS if they are to succeed. It is also claimed that problem solving requires patience, persistence, perseverance, and willingness to take risks [19]. Students in the problem-posing approach class displayed more patience and persistence in problem solving difficulties than students in the perseverance, willingness, and self-confidence classes [20]. Charles, Lester, and O'Daffer [21] divided ATPS into three categories: perseverance, self-confidence, and willingness. In educational research, perseverance (PE), self-confidence (SC), and willingness (WL) are the most influencing factors in mathematical problem solving. Many recent studies support the classification of attitudes into these three subcategories [15], [22].

In order to improve mathematical comprehension students must require PE while solving a problem [23]. So the PE of a student should be developed for a better understanding of Mathematics and its achievement [24]. It has been established that the association between cognitive activity and mathematical achievement was partially mediated by PE [25]. Saleh [26] mentioned that to succeed in algebra, students must have PE in reading and understanding the offered problems. He also points out that students have a high level of PE to keep up until they find a solution, and their efforts must continue until they solve the problem. The proper problem-solving instruction enhances students' PE, which leads to a higher PSA in Mathematics [27]. Thus, there is a significant relationship between PE and PSA [28].

In recent years, SC has emerged as one of the most important factors influencing students' Mathematics achievement. SC has a key role in learning Mathematics and problem solving, which are necessary to have outstanding achievement [29]. According to Saleh [26], a student's high SC in their mathematical ability also assists them in solving more difficult problems. Also, the SC of secondary school students is influenced by problem-solving skills [30]. Several studies have found that SC has a positive and moderate effect on Mathematics achievement [31]. In contrast, other studies reveal that there is no correlation between student SC and academic achievement [32].

WL is one of the most important aspects of education and has a major impact on student achievement [33]. The WL to solve a problem in Mathematics in general and algebra, in particular, have a significant role in Mathematics achievement. Excellent students have a high level of WL to work out algebraic problems in comparison to poor and average students [34]. In a similar study, it was also found that brilliant students have a superior level of WL in the case of PSA [26]. Also, the study reports of students from Nigerian universities have a moderate correlation between WL to engage in problem-solving ability and PSA [35].

Gender influences one's attitudes toward Mathematics and problem solving. Numerous studies have revealed a gender gap in attitudes toward Mathematics [36], [37]. Previous research has established that male students have a more positive attitude toward Mathematics than female students [38]. Moreover, it was also found that male students were found to be more efficient than females in the case of problem solving [39]. However, other studies indicated that female students had considerably higher problem-solving abilities and a better scientific attitude than male students [40], [41]. In a study, Arslan, Yavuz, and Deringol-Karatas [42] found that female students have significantly better ATPS scores than male students. On the other hand, many investigations have found no substantial difference between male and female ATPS in Mathematics [12]. Studies by Zakaria and Yusoff [15] found no significant mean difference in students' ATPS in algebra when

gender was considered among Malaysian students. In Nigerian senior secondary students, it was also found that there was no significant difference between male and female students' ATPS in algebra [43].

Aside from gender, students' attitudes toward Mathematics are influenced by the type of school [38], [44]. Previous research has indicated that private (PVT) secondary schools had more scientific and mathematical attitudes than government (GOVT) secondary schools [45]. In a recent study, it has also been established that PVT school students have a higher attitude than GOVT school students [46]. On the other hand, GOVT school students had a better attitude toward Mathematics than PVT school students [47].

Considering all the supports and findings, an attempt has been made to study the effects of attitude toward algebraic problem-solving achievement. The main purpose of this study is to examine the effects of ATPS in algebra with respect to gender and type of school. Another purpose is to investigate the contribution of the predictor variables of ATPS in algebra to the prediction of Pathos. In accordance with the purposes, the present study is designed to test the following hypotheses: i) There is no significant difference between gender and students' ATPS in algebra (H_o^1); ii) There is no significant difference between the type of school and students' ATPS in algebra (H_o^2); iii) There is no significant contribution of predictor variables of ATPS in algebra to the prediction of PSA (H_o^3).

2. RESEARCH METHOD

For the study, a descriptive survey is adopted in order to investigate the effects of ATPS in algebra. The sample of the study consisted of secondary school students. For that purpose, 200 class IX students are randomly selected from GOVT and PVT schools in the Morigaon district of Assam, India out of which 95 students are chosen from GOVT schools and 105 are chosen from PVT schools. Also, out of 200 students, 106 are male and 94 are female. The survey participants are randomly selected to ensure that everyone had an equal chance of participating in the study [48].

Two instruments are employed to collect the data. They are the algebraic attitude scale (AAS) and problem-solving test (PST). The AAS is used to determine students' ATPS in algebra. The AAS instrument is adapted from Charles, Lester, and O'Daffer [21]. This instrument consists of three subscales: perseverance (PE), self-confidence (SC), and willingness (WL). The AAS is a Likert five-point scale consisting of 20 items. For each item numerical scores are considered as 5=Strongly agree, 4=Agree, 3=Neutral, 2=Disagree, and 1=Strongly disagree. The reliability scores of these three sub-scales: PE is 0.72, SC is 0.71, and WL is 0.77. The reliability of these three subscales is measured by Cronbach alpha with the help of SPSS 26.0.

The PST is used to determine students' PSA in algebra. The PST instrument is based on the class IX standard syllabus according to the Secondary Education Board of Assam (SEBA). The PST contains 20 multiple-choice items that were verified and validated by some subject experts of secondary schools.

The data is analyzed with the help of the SPSS 26.0 version. Descriptive statistics and inferential statistics are used to test the hypotheses. The t-test is done to find out the significant difference between students' ATPS based on gender and type of school. Multiple regression analysis is used to investigate the contribution of predictor variables (PE, SC, and WL) on PSA in algebra.

3. RESULTS

From Table 1, the t-value 6.650 is statistically significant as a p-value 0.000 ($p<0.05$). So, the null hypothesis is Ho^1 is rejected. Hence, there is a significant mean difference between gender and students' ATPS in algebra. The mean score and standard deviation (SD) of male students are 3.65 and 0.442, while the mean score and SD of female students are 3.18 and 0.539. The gender difference in ATPS score is depicted in the bar diagram in Figure 1.

From Table 2, the t-value of 3.986 is statistically significant as the p-value is <0.05. So, the null hypothesis Ho^2 is rejected. Hence there is a significant difference between the type of school and ATPS in algebra. The mean score and SD of GOVT school students are 3.53 and 0.472, while the mean score and SD of PVT school students are 3.25 and 0.518. Also, the difference in ATPS score based on school type is depicted in the following bar diagram in Figure 2.

Table 1. Difference between gender and students' ATPS

Gender	N	Mean	SD	Std. error mean	T	Sig.
Male	106	3.64	0.442	0.043	6.650	0.000
Female	94	3.18	0.539	0.056		

Table 2. Difference between the type of school and students' ATPS

School type	N	Mean	SD	Std. error mean	t	Sig.
GOVT	95	3.53	0.472	0.048	3.986	0.000
PVT	105	3.25	0.518	0.051		

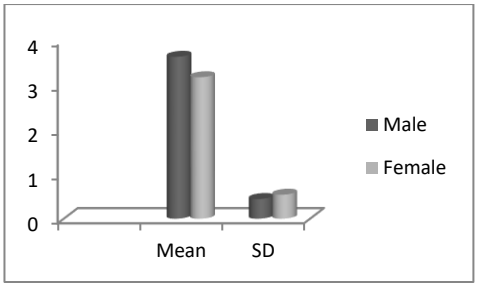

Figure 1. Student's mean and SD score based on gender

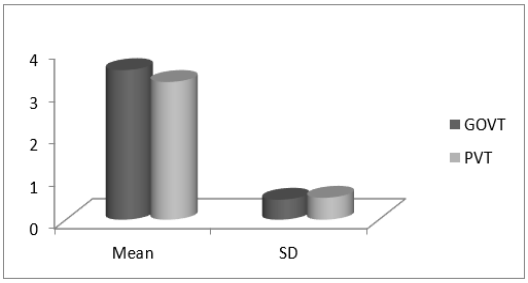

Figure 2. Student's mean and SD score based on type of school

The result of multiple linear regression analysis as presented in Table 3 shows that the overall model is highly significant as F(3,196)=144.338, p<0.05 (from the ANOVA as shown in Table 4). Hence, $H_o{}^3$ is rejected and there is a significant contribution of predictor variables of ATPS to the prediction of PSA. Since the model is significant, simultaneous influences exist between predictor variables (PE, SC, and WL) and the algebraic PSA. Table 3 shows that the value of the coefficient of determination (R^2) is 0.688. This indicates that 68.8% variation in PSA can be explained by the predictor variables (PE, SC, and WL). The remaining 31.2% variation can be explained by the other variables [49].

Table 3. Multiple regression model of PSA

Model summary				
R	R Square	Adjusted R Square	Std. error of the estimate	R Square Change
0.83	0.688	0.684	0.264	0.688

Table 4. ANOVA

Model	Sum of squares	Df	Mean square	F	Sig.
Regression	30.068	3	10.023	144.338	0.000
Residual	13.610	196	0.069		
Total	43.678	199			

The contribution of the predictor variables of ATPS in algebra to the prediction of PSA is stated in the coefficients in the sig. column as shown in Table 5. The predictor variable PE has a t value of 5.979 and the corresponding value of unstandardized beta coefficient (b_1) is 0.248, both are significant as p<0.05. So, PE has a significant contribution to problem solving achievement. Similarly, SC (t=5.053, b_2=0.229, p<0.05) and WL (t=4.931, b_3=0.238, p<0.05) made a significant contribution to problem-solving achievement. Since the B coefficients (i.e., b_1, b_2, b_3) are positive PE, SC, and WL have a positive relationship to the prediction of PSA in algebra. Also, PE has a higher B coefficient value (0.332) than the value of SC (0.300) and WL (0.309). So, PE has a better contribution to the prediction of PSA in algebra as compared to SC and WL. From all these the prediction model of the linear equation, they can be written as (1).

Table 5. Multiple linear regression for algebraic PSA

	Unstandardized coefficients		Standardized coefficients	t	Significance
	B	Std. Error	Beta		
(Constant)	0.820	0.119		6.880	0.000
PE	0.248	0.040	0.332	5.979	0.000
SC	0.229	0.045	0.300	5.053	0.000
WL	0.238	0.050	0.309	4.931	0.000

$$Y=0.820+0.248*x+0.229*y+0.238*z. \quad (1)$$

Where, Y=PSA in algebra, x=PE, y=SC, and z=WL.

From the regression model in (1), the positive unstandardized B coefficient for PE (0.238) as a predictor of PSA in algebra indicated that there is about a 0.238 increase in PSA for each unit increase in PE. This means that the PSA in algebra increases as PE increases. Similarly, an increase in PSA in algebra leads to an increase in SC and WL, respectively. From the linear, it is clear that PE has more contribution to the prediction of PSA in algebra.

4. DISCUSSION

The study reveals that there is a significant mean difference between gender and ATPS in algebra. This result contradicts the findings of [15], [43] that there is no significant mean difference between genders in their ATPS in algebra. Also, the mean ATPS score of male students (3.64) is greater than that of female students (3.18). The higher mean value indicates that male students have a significantly higher ATPS in algebra. This finding is similar to the study report of Sarma and Rabha [38], as male students have significantly better ATPS. In contrast, Arslan, Yavuz, and Deringol-Karatas [42] found female students have a higher ATPS score than males.

The study found that there is a significant mean difference between types of schools and ATPS in algebra. In earlier research, it was found that there is a significant mean difference in students' attitudes toward Mathematics in terms of school type [50]. Also, the mean score of algebraic ATPS of GOVT schools (3.53) is greater than the PVT schools (3.25). Thus, GOVT schools' students have a higher algebraic ATPS than PVT schools' students. This result is identical to the study report of previous research [47] that GOVT school students have a higher scientific attitude than PVT. However, some others reported that PVT schools' mean score is higher than GOVT schools [46].

The finding also signifies that the predictor variables (PE, SC, and WL) have a significant positive relationship to the PSA in algebra. From the ANOVA table, the contribution of the predictor variables (PE, SC, and WL) has 68.8% to the prediction of PSA in algebra, and the remaining 31.2% can be explained by other factors. It is also reported that the predictor variables have a significant relationship with algebraic PSA [12] and our finding supports it. However, Agustyani, Priatna, and Martadiputra [20] exhibited that another variable (patience and persistence) has more contribution than PE, SC, and WL in problem solving. From the regression model, it is also found that PE significantly contributes more to the prediction of algebraic PSA than SC and WL.

5. CONCLUSION

The finding reveals that there are statistically significant differences in students' ATPS with respect to gender and type of school. Thus, ATPS in algebra is influenced by gender and type of school. There are simultaneous influences that exist between the predictor variables (PE, SC, and WL) and the prediction of PSA in algebra. The finding also reveals that PE, SC, and WL have a significant positive relationship with the PSA in algebra. The predictors have a 68.8% contribution to the prediction of PSA in algebra. From the regression model, it can be concluded that PE has a higher contribution to the prediction of PSA in algebra as compared to SC, and WL. Thus, PE is a better predictor of PSA in algebra.

The present study reveals that students' ATPS is influenced by gender and type of school. Teachers should be encouraged to use better teaching methods that would stimulate students' positive ATPS. In the case of female students, special attention should be made to develop their mathematical attitude while solving a problem. Also, along with government schools, teachers' private school teachers also should be trained by sending them to attend workshops, seminars, and conferences. in order to promote the teaching-learning process in Mathematics. Also, the sub-categories of ATPS i.e., the predictors have significant contributions to algebraic PSA. So that educators and school authorities should make an effort to provide support in the form of explanations, modeling, coaching, and other forms of assistance, as well as a conducive environment that encourages students' overall ATPS that can enhance their PSA in Mathematics.

ACKNOWLEDGMENTS

The authors would like to express gratitude to all government and private secondary school teachers who helped us for collecting data from their schools to carry out our study.

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