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Teacher-student relationship and students' mathematics achievement: Mediating roles of students' perception of mathematics, students' self-efficacy, and cooperative learning strategies

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ABSTRACT

The study examined the mediating roles of students' perception of mathematics, students' self-efficacy and cooperative learning strategies in the relationship between teacher-student relationship and students' mathematics achievement in all the senior high schools at Atwima Nwabiagya North District. The study was carried out using the descriptive survey design. The target population was second-year students. Through purposive, proportionate stratified, and simple random sampling techniques, questionnaires were administered to 346 second year students, however, 320 questionnaires were returned. The data collected were analyzed using structural equation model with bootstrap samples. It was found that teacher-student relationship was significant negative predictor of students' mathematics achievement. The study also discovered that, students' perception of mathematics, students' self-efficacy and cooperative learning strategies were partially mediated the relationship between teacher-student relationship and students' mathematics achievement. It was suggested based on the findings that mathematics teachers should be mindful of their relationship with the students, employ varieties of techniques when dealing with students with bad perception of mathematics and also consider the kind of collaborative learning techniques to be adopted in order to accelerate students' mathematics achievement.

Keywords: teacher-student relationship, self-efficacy, perception, cooperative learning strategies, mathematics achievement

INTRODUCTION

Mathematics is the science that deals with the application of the cognitive domain and making computation. Though mathematics is seen as abstract, it is useful in a variety of industries, including design, software engineering, engineering, development, woodworking, and many more. (Kusmaryono, 2014). The techniques and skills developed from mathematics have been identified as essential not only for academic achievement but also for effective functioning in everyday life (Hodanova & Nocar, 2016). Learners' life experiences have a significant impact on how well they succeed in arithmetic (Ezenweani, 2006). Learners' arithmetic performance has been a key source of concern for both the public and private education sectors. Scholars have succeeded in finding a variety of variables that greatly affect learners' results, notably in arithmetic, over the last three decades (Reardon et al., 2009). Various contributing variables such as the instructor-learner connection, self-efficacy, learners' perceptions of arithmetic, cooperative learning methods, and others, according to the researchers, have a substantial influence on mathematics achievement.

The instructor-learner connection had shown to have a negative influence on mathematics achievement in multiple research investigations. (Arthur et al., 2017). According to research, the relationship between instructors and learners has a major impact on the arithmetic achievement of learners (Hughes & Kwok, 2007). If teachers want to create a great learning environment, they must first build a favorable relationship with their learners. If a kid sees their teacher as a "friend," they are more likely to get higher results (Pianta, 1999). Many learners assume that their poor arithmetic performance is due to a lack of chemistry between teachers and learners. Teachers usually approach learners who have high-capacity levels and who are enthusiastic about the subject. Low-capacity learners are negatively impacted by this separation. Again, arithmetic is seen as a tough subject, and a healthy connection between instructor and learner can go a long way toward learners' achievement (Appiah et al., 2022)

Self-efficacy is defined by Pajares (2002) as the degree of a person's confidence in his capacity to do the things that they attempt. Self-efficacy, according to Ormrod (2006), is the belief in one's ability to deliver in a specific way in order to attain a specified goal. Later events in a learner's life are influenced by their belief in their ability to achieve predetermined standard of achievement (Qi & Xu, 2019). In their research, learners who have a high level of self-confidence perform better academically than those who have a low level of self-confidence, according to Sharon and Vialle (1998). Instructors link self-confidence to a person's capacity and behavior when carrying out the task. Self-efficacy has a significant impact on one's actions, effort, and method of completing tasks, resulting in improved abilities and increased confidence in the intended outcomes.

From a physical, mental, and physiological standpoint, perception can be defined. In any case, the scope of this inquiry will be limited to the modification offered by Allport (1935), which is how we judge the people we meet. Learners' conceptions of mathematics in this study include components derived from prior experiences, the learner's societal environment, and those derived from classroom experiences (Hannula, 2007). Males, on average, have a strong positive impression of mathematics, according to study (Kaasila et al., 2006). Educators have progressed and refined mathematics academic practices during the past three decades, which many views to be a catalyst for improving mathematics learners' academic accomplishment. Manipulative materials, cooperative group work, arithmetic discourse, questioning and creating conjectures, writing about arithmetic, specific problem-solving approaches, and the use of calculators and computer systems are only a few of the most effective mathematics instructional practices (Zemelman et al., 1992). These tactics are mostly relevant to educators and those concerned with improving children's mathematics achievement. Cooperative learning methods for mathematics teaching, in particular, have been identified by multiple research as one of the simplest instructional strategies for increasing the academic overall performance of normal middle-grade college learners (Slavin 1995).

Scholars and education stakeholders have expressed concern about learners' poor performance in mathematics and this terrible arithmetic performance levels have had a negative impact on the country's science and technology (Chand et al., 2021). As a result of this abysmal performance, a great deal of research had been done on some factors that influence students' mathematics achievements (Callaman & Itaas, 2020; Mutodi & Ngirande 2014; Lavasania & Khandana, 2011; Appiah et al., 2022). Following a thorough study of the literature, mathematics achievement can be predicted by factors such as teacher-student relationship, students' self-efficacy, students' perception of mathematics and cooperative learning strategies with varying results and conclusions. (Callaman & Itaas, 2020; Mutodi & Ngirande 2014; Lavasania & Khandana, 2011; Appiah et al., 2022).

The current problem is that, out of the studies reviewed, majority of these factors were predicting mathematics achievement disjointly and the few ones that combined two or more factors in predicting mathematics achievement were looking into only the direct influence. The ability to combine two or more of such variables and their direct and indirect influence on mathematics achievement has not been adequately studied. In order to bridge this gap, the researcher intended to investigate the mediating roles of students' perception of mathematics, students' self-efficacy, and cooperative learning strategies on the relationship between teacher-student relationship and students' mathematics achievement.

Research Hypothesis

The study tested the following research hypothesis:

1. **H0.** Teacher-student relationship will not significantly predict mathematics achievement.

   H1. Teacher-student relationship will significantly predict mathematics achievement.

2. **H0.** Students' perception of mathematics will not mediate the relationship between teacher-student relationship and mathematics achievement.

   H1. Students' perception of mathematics will mediate the relationship between teacher-student relationship and mathematics achievement.

3. **H0.** Students' self-efficacy will not mediate the relationship between teacher-student relationship and mathematics achievement.

   H1. Students' self-efficacy will mediate the relationship between teacher-student relationship and mathematics achievement.

4. **H0.** Cooperative learning strategies will not mediate the relationship between teacher-student relationship and mathematics achievement.

   H1. Cooperative learning strategies will mediate the relationship between teacher-student relationship and mathematics achievement.

MATERIALS AND METHOD USED

Study Design and Instruments

Before beginning data collection, school leaders were consulted regarding when their respective schools would be visited by the researchers to accumulate the essential data. At the point when the researchers showed up at the schools, they gave a letter to the authority mentioning the data collection approval inside each school. The purposive sampling procedure was utilized to gather data (Fraenkel et al., 2005). Overall, two schools were chosen from the Kumasi Metropolitan in the Ashanti Region of Ghana. The study accommodates a total of 320 students (166 male and 158 female) with an average age range from 16 -18 years old. Students were selected from Senior High schools (SHS2). The study did not include SHS1 and SHS3 students since they were not

Table 1. Learners background information (n=320)

Background	Frequency (n)	Percentage (%)
Gender		
Male	166	51.9
Female	154	48.1
Age		
13-15	66	20.6
16-18	242	75.6
19-21	9	2.8
22-25	2	0.6
25 and above	1	0.3
Religion		
Christian	284	88.8
Muslim	33	10.3
Traditional worshipper	2	0.6
Others	1	0.5
Program		
Science	96	30.0
General arts	122	38.1
Business	17	5.3
Home economics	45	14.1
Visual art	20	6.3
Agriculture	20	6.3
Level		
Form 2	320	100.0

Note. Source: Field Survey (2022)

in a good position to give reliable responses. Students were found in their classroom setting while learning. With approval from the Head Teacher (HT), the teacher would invite the researchers, and afterward permit them to clarify every one of the subtleties of the exploration, just as how the questionnaire would have been replied. Students had to accept voluntarily to participate in the research before being given questionnaires. Students were free to ask questions before and during the filling of the questionnaire about the research or the item for more clarifications. To provide answers to the three research questions based on the five constructs, one dependent variable, three mediating variables and one independent variables, the present study employed a descriptive survey design. The researchers themselves designed the questionnaires based on a sample of research hypotheses. This means the questionnaire items were centered on five constructs: (i) Efficacy of students, (ii) Teacher-Students' relationship, (iii) Students' Perception of Mathematics, iv) Cooperative Learning Strategies and v) Students Mathematics Achievement. Questionnaires were administered in English to students. Apart from personal information items, the questionnaire for students contained about 49 question items. Items within the questionnaire were ranked in a 5- type Likert scale ranging from 1 (Strongly agree) to 5 (strongly disagree). The validity of items was checked to ensure that the content and the format of the questionnaire were appropriate, meaningful, and correct towards the research questions and constructivism theory that will guide this study.

1. Efficacy of students,
2. Teacher-students' relationship,
3. Students' perception of mathematics,
4. Cooperative learning strategies, and
5. Students mathematics achievement.

Questionnaires were administered in English to students. Apart from personal information items, the questionnaire for students contained about 49 question items. Items within the questionnaire were ranked in a 5-type Likert scale ranging from 1 (strongly agree) to 5 (strongly disagree). The validity of items was checked to ensure that the content and the format of the questionnaire were appropriate, meaningful, and correct towards the research questions and constructivism theory that will guide this study (**Appendix A**).

The internal consistency of the questionnaire was also checked and calculated using Cronbach's alpha approach. For data analysis and presentation, frequency tables were used for the background of students. Also, structural equation model (SEM) was used. To check for the validity and reliability of the data set, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were employed.

The study included both male and female students, as stated in **Table 1**. The results show that 51.9% of the students were males, while 48.1% were girls, with 166 males and 154 females. The consequence is that at three SHSs in Atwima Nwabiagya North District, there are more male students than girls. The responses were evenly divided among the age ranges on the questionnaire, as shown in **Table 1**. **Table 1** shows that 66 students, representing 20.6%, were between the ages of 13 and 15, while 242 students, representing 75.6%, were between the ages of 16 and 18. Surprisingly, nine of the students, representing 2.8%, were between the ages of 19 and 21, two of the students, as representing 0.6%, were between the ages of 22 and 25, and just one of the students, representing 0.3%, was between the ages of 26 and above. The majority of students in three SHS in Atwima Nwabiagya North District were between the ages of 16 and 18.

Table 2. Values of the study items' reliability

Constructs	Number of items	Cronbach's alpha value
Students' self-efficacy (SSE)	4	0.990
Teacher-student relationship (TSR)	5	0.917
Students' perception of mathematics (SPM)	4	0.884
Cooperative learning strategies (CLS)	5	0.982
Students' mathematics achievement (SMA)	4	0.965

Note. Source: Field Survey (2022)

In addition, **Table 1** shows that 284 of the 320 respondents were Christians, 33 were Muslims, two were traditional worshipers, and one had a religion other than the one specified in the questionnaire. Among the responders, 96 were scientific students, 122 were general arts students, 17 were business students, 45 were home economics students, 20 were agricultural students, and 20 were visual art students. Also, from the descriptive statistics, all the 320 respondents were form 2 students.

Validity and Reliability of Instrument

The 92.5% response rate was deemed exceptional and representative of the sample community on this basis. The researcher accurately checked the questionnaire in multiple ways across various strategies. The questionnaire was personally created with reference to the purpose of the study and relevant research hypotheses to guarantee that it measured what it was supposed to measure. Also, some instructors were given a draft to review to see if the response items were appropriate. Their thoughts and criticisms helped to improve the instruments' authenticity and content. In addition, the questionnaire was sent to the supervisor for review and expert guidance on any necessary corrections or amendments. On the basis of these assumptions, the researcher assumed the instruments' face and content validity. To provide a valid and accurate questionnaire free of ambiguities, a pre-test was conducted at Barekese Senior High School. The researcher clarified and reframed some of the difficulties in the research instrument that had been regarded as ambiguous. The importance of the concerns has been considered and dealt appropriately. The test method's reliability is critical for ensuring consistency in the production of reliable response and for instilling confidence in future strategies and study decisions in order to achieve effective outcomes. Time, type of instruments to be used, and group reaction are all factors in measuring consistency and reliability, according to Cohen, Marion, and Morrison (2003). Cronbach's Alpha (α) was used to assess items internal consistency. All the alpha values of the constructs were above 0.60 which deemed appropriate according to Sekaran and Bougie (2010).

From **Table 2**, Cronbach's alpha coefficient of all the five constructs with 19 items was 0.677. This indicates a good consistency of the items. Also, Cronbach's alpha value of each of the five constructs were computed. It can be seen from **Table 2** that students' self-efficacy as a construct with four items was having alpha value of 0.990, teacher-student relationship with five items was having alpha value of 0.917, student perception of mathematics with four items was having alpha value of 0.884, cooperative learning strategies with five items was having an alpha value of 0.982, and student mathematics achievement with four items was having an alpha value of 0.965.

RESULTS

Results of Exploratory Factor Analysis

Table 3 shows a summary of the results of EFA. EFA can be defined as a technique that focuses on interconnected factors. EFA is a variable decrease approach that distinguishes the latent variables and the factors that underpin the character of a group of

Table 3. Exploratory factor analysis (Source: Field Survey, 2022)

	Components				
	1	2	3	4	5
CLS1	0.945				
CLS2	0.948				
CLS3	0.948				
CLS4	0.969				
CLS5	0.949				
TSR1		0.757			
TSR2		0.930			
TSR3		0.885			
TSR4		0.929			
TSR5		0.629			
SSE1			0.967		
SSE2			0.969		
SSE3			0.957		
SSE4			0.970		
SMA1				0.867	
SMA2				0.922	
SMA3				0.776	
SMA4				0.911	

Table 3 (Continued). Exploratory factor analysis (Source: Field Survey, 2022)

	Components				
	1	2	3	4	5
SPM1					0.857
SPM2					0.880
SPM3					0.761
SPM4					0.830
Total variance explained					0.851
Barlett's test of sphericity			Approximated Chi-square value		10,862.725
			df		231
			Significance		.000
[a]Determinant					6.648E-16

Note. Extraction method: Principal component analysis; Rotation method: Varimax with Kaiser normalization; & Rotation converged in 5 iterations

variables, according to Surh (2005). **Table 3** reveals that Kaiser-Meyer-Olkins measure of sampling adequacy is 0.851, that is significantly higher than the required factoring value of 0.5. According to Hair et al. (2010), this is a worthy worth, indicating that the items have a strong link. With a Chi-square score of 10,862.725 and 231 levels of degree of freedom, Bartlett's sphericity test proved significant. Bartlett's test was having a significant p-value of .000 ($p<.001$), indicating that the elements have been considered and that the correlations are not close to zero.

The determinant of 6.648E-16 from **Table 3** is also deemed to be quite excellent because it is much more than zero. The researcher used factor analysis to determine the required variables to be extracted, which was five, as per the questionnaire's instructions. Overall number of five components were selected and rotated from Table 3, yielding a cumulative variance explained of 86.606 percent. The rotated component matrix is also shown, along with a turn varimax and factor loading. The rotational varimax technique was used since it reduces the number of complex parameters while potentially increasing the normal yield. The meaning and relevance of the items were examined to determine if they should be kept or removed. Iteratively, items with low factor ladings and those loaded at different components were removed, and the fit indices were examined each time an item is being removed. Because this load of items was in varied develop measures, the Rotated Component matrix revealed that 25 items should be dropped. All of the factor loadings under each component in **Table 3** were larger than 0.5. **Table 3** contains the remaining items.

Result of Confirmatory Factor Analysis

The results of CFA are summarized in **Table 4**. CFA was persuaded to approve the measurements adopted during EFA. The data was acquired from 320 samples, and AMOS 23.0 was used to test five components of the measurement model. To improve the model, a few modifications were made. The removal of items with low factor loadings was one of the techniques.

Table 4. Confirmatory factor analysis

Constructs	Standard factor loading
Students' self-efficacy (SSEF): CA=990; CR=0.992; & AVE=0.968	
(SSE1) I am confident with mathematics.	1.042
(SSE2) I know how to attack difficult questions in mathematics.	1.060
(SSE3) I believe I am the type of person who is good at mathematics.	0.893
(SSE4) I get high scores in mathematics.	0.930
Teacher students' relationship (TSRH): CA=917; CR=0.917; & AVE=0.691	
(TSR1) Has mastery of the subject matter.	0.825
(TSR2) Imposes proper discipline and is not lenient in following the prescribed rules.	0.859
(TSR3) Uses various strategies teaching aids /device and technique in presenting lessons.	0.941
(TSR4) Has an appealing personality with good sense of humor.	0.850
(TSR5) Show interest in all students irrespective of your ability.	0.654
Students perception of mathematics (SPMT): CA=0.884; CR=0.892; & AVE=0.676	
(SPM1) I think that mathematics is useful in life.	0.884
(SPM2) I enjoy learning mathematics.	0.868
(SPM3) I rate mathematics higher than all the other core subjects.	0.687
(SPM4) I perceive mathematics to be a difficult subject.	0.835
Cooperative learning strategies (CLST): CA=982; CR=0.979; & AVE=0.905	
(CLS1) When we work together in small groups, we all receives the same grade.	0.924
(CLS2) In class, we learn more when we work together.	0.942
(CLS3) I should get along with other students better than I do.	0.958
(CLS4) I like to participate in team.	0.987
(CLS5) I would rather work in team than my own.	0.944
Students' mathematics achievement (SMAT): CA=965; CR=0.984; & AVE=0.941	
(SMA1) Mathematics make me think fast.	1.023
(SMA2) Mathematics is more enthusiastically for me than a significant number of my schoolmates.	0.896
(SMA3) I get good marks in mathematics.	1.063
(SMA4) I can perform excellently well if I do not give up.	0.886

Note. AVE: Average variance extracted; CA: Cronbach's alpha; CR: Construct reliability; Source: Field Survey, 2022; & Model fit indices: Chi-square (CMIN)=276.006; CMIN/df=1.533; Tucker-Lewis index (TLI)=0.989; RMSEA=0.041; Degree of freedom (df)=180; Comparative fit index (CFI)=0.991; & Goodness-of-fit index (GFI)=0.933

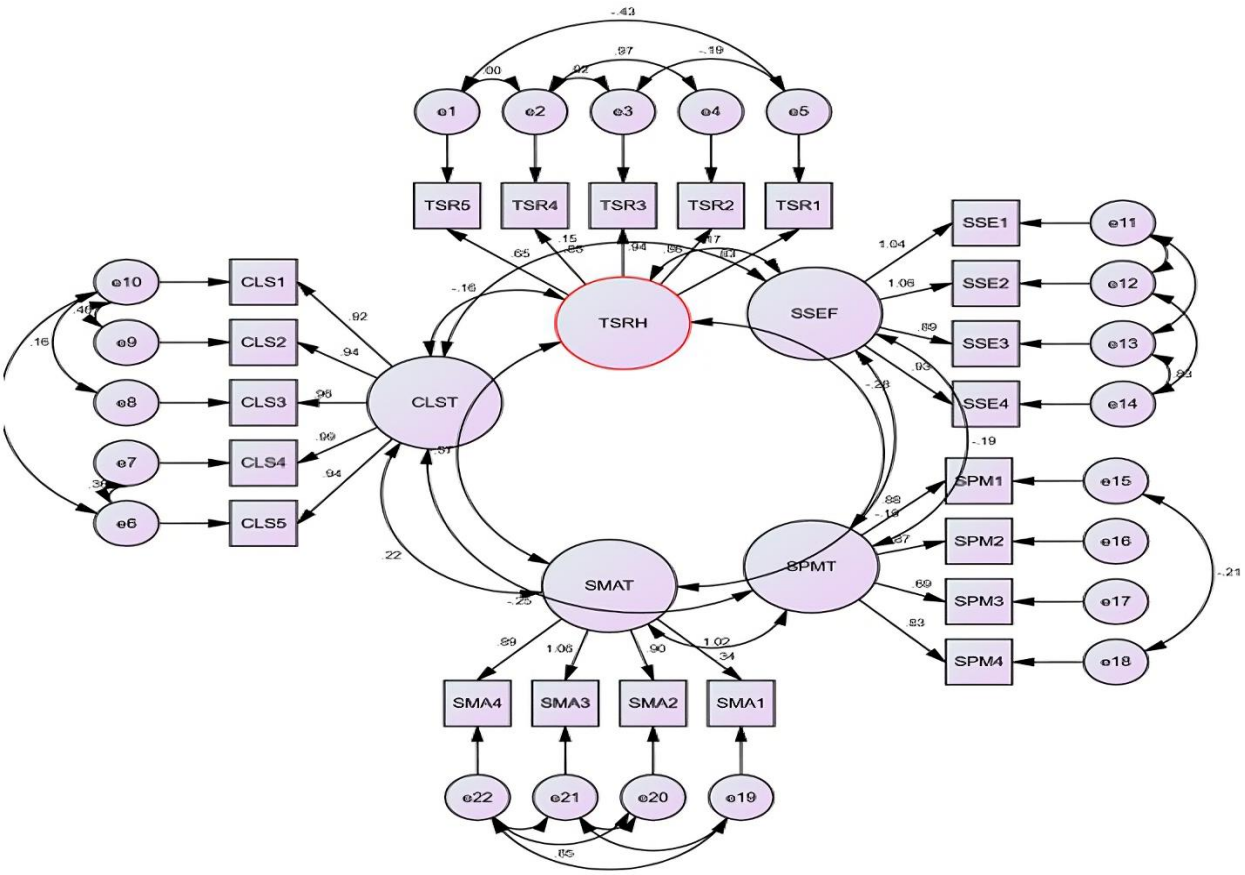

Figure 1. Confirmatory factor analysis of the five constructs (Source: Field Survey, 2022)

Table 4 summarizes CFA, with SFL denoting standard factor loading. **Table 4** provided information from 320 samples, and AMOS 23.0 was used to test five components of the measurement model. To improve the model, a few changes were made. The deletion of items with low factor loadings was one of the adjustments. The matching index value was p=0.000, the normed Chi-square=276.006 with 180 degrees of freedom, CFI=0.991, and RMSEA=0.041 after the corrections, according to the general model. The ratio of Chi-square to degree of freedom, which was 1.533 deemed useful for nested model, since it was less than three (Hu & Bentler, 1999). CFI produced a result of 0.991. The score was higher than 0.95, indicating that the model is valid and that the model and the data are highly compatible (Hu & Bentler, 1999). GFI's subsequent value of 0.933 indicates that the final model is acceptable. Furthermore, RMSEA for this study was 0.041, which is less than 0.06 to 0.08, indicating that RMSEA was acceptable (Hu & Bentler, 1999). As a result, the essential aspect of the five constructs is valid and acceptable. The other fit indices, NFI and TLI, were both above 0.9, indicating that the 5-factor model was well-fit. For good convergent validity, factor loadings and CR should not be less than 0.707. **Table 4** shows that there are twenty loadings more than 0.707 and two loadings between 0.6 and 0.707. Correlating the measurement error between the items is recommended based on modifications index (MI).

In general, the model is acceptable and provides factorial validity to the five dimensions' determinants among respondents. The structural model of CFA of the five constructs is being presented in **Figure 1**.

Path Analysis

The summary of the hypothetical analyses results (direct and indirect effect) as well as the model fit indices of the path analysis have been presented in **Table 5**.

Chi-square value of 308.782 in path analysis demonstrates the goodness of fit model, as shown in **Table 5**. Furthermore, RMSEA of 0.046 indicates a strong fit model for an absolute fit index with a 95% confidence interval because it is less than 0.08, and the two fit indices, NFI and TLI, were both greater than 0.9, indicating a very excellent fit to the 5-factor model (Hu & Bentler, 1999). The direct effect of the exogenous variable on the endogenous variables is also significant, as seen in **Table 5**. The p-value ($p<0.005$) indicates statistical significance for the direct effect of students' perception (SPMT) and cooperative learning techniques (CLST) on students' mathematics achievement (SMAT). As a result, learners' perception and the collaborative learning techniques used in teaching the subject as a predictor of mathematical achievement have favorable influence on learners' mathematics accomplishment. On the other hand, with path coefficients of -1.730 and -0.143, the teacher-student relationship (TSRH) and students' self-efficacy respectively, appear to have a negative impact on mathematics achievement of learners. **Table 5** shows the results of the indirect influence of the instructor-learner connection on learners' mathematical accomplishment, as well as the specific indirect effect (SIE) of each mediator. Based on the research hypotheses/objectives, the essential aspects of the direct and indirect effect have been elaborated below.

Figure 2 presents the path diagram of SEM.

Table 5. Summary of the hypothetical analyses results (Source: Field Survey, 2022)

Path estimate		Parameters	Estimate	SE	BCpCI 95% CI		p-value
					LL	UL	
TSRH→CLST		p1	-0.397	0.159	-0.604	-0.217	0.012
TSRH→SPMT		p6	-0.726	0.160	-1.009	-0.535	0.000
TSRH→SSEF		p4	-0.957	0.219	0.660	1.341	0.000
CLST→SMAT		p2	0.314	0.057	0.228	0.443	0.000
SPMT→SMAT		p7	0.384	0.066	0.280	0.552	0.000
TSRH→SMAT		P3	-1.730	0.211	-2.406	-1.010	0.000
SSEF→SMAT		p5	-0.143	0.042	-0.208	-0.089	0.000
Model fit indices: CMIN=308.782; df=183; CMIN/df=1.687; CFI=0 .988; TLI=.985; IFI=0. 989; GFI=0.925; & RMSEA=.046							
Specific indirect effect (SIE) mediators							
SIE1	TSRH→CLST→SMAT	p1*p2	-0.125	0.030	-0.205	-0.078	0.000
SIE2	TSRH→SSEF→SMAT	p4*p5	-0.136	0.033	-0.217	-0.083	0.000
SIE3	TSRH→SPMT→SMAT	p6*p7	-0.279	0.055	-0.425	-0.192	0.000
Total indirect effect (TIE) & total effect (TE)							
TIE	SIE1+SIE2+SIE3		-0.540	0.099	-0.787	-0.388	0.000
TE	TIE+p3		-2.270	0.391	-3.017	-1.525	0.002

Note. CI: Confidence interval; LL: Lower limit; UL: Upper limit; SE: Standard error; TSRH: Teacher-student relationship; CLST: Cooperative learning strategies; SPMT: Students' perception of mathematics; SSEF: Students' self-efficacy; SMAT: Student mathematics achievement; & BCpCI: Bias corrected & accelerated 95% CI for 2,000 bootstrap resamples of sample size of 320

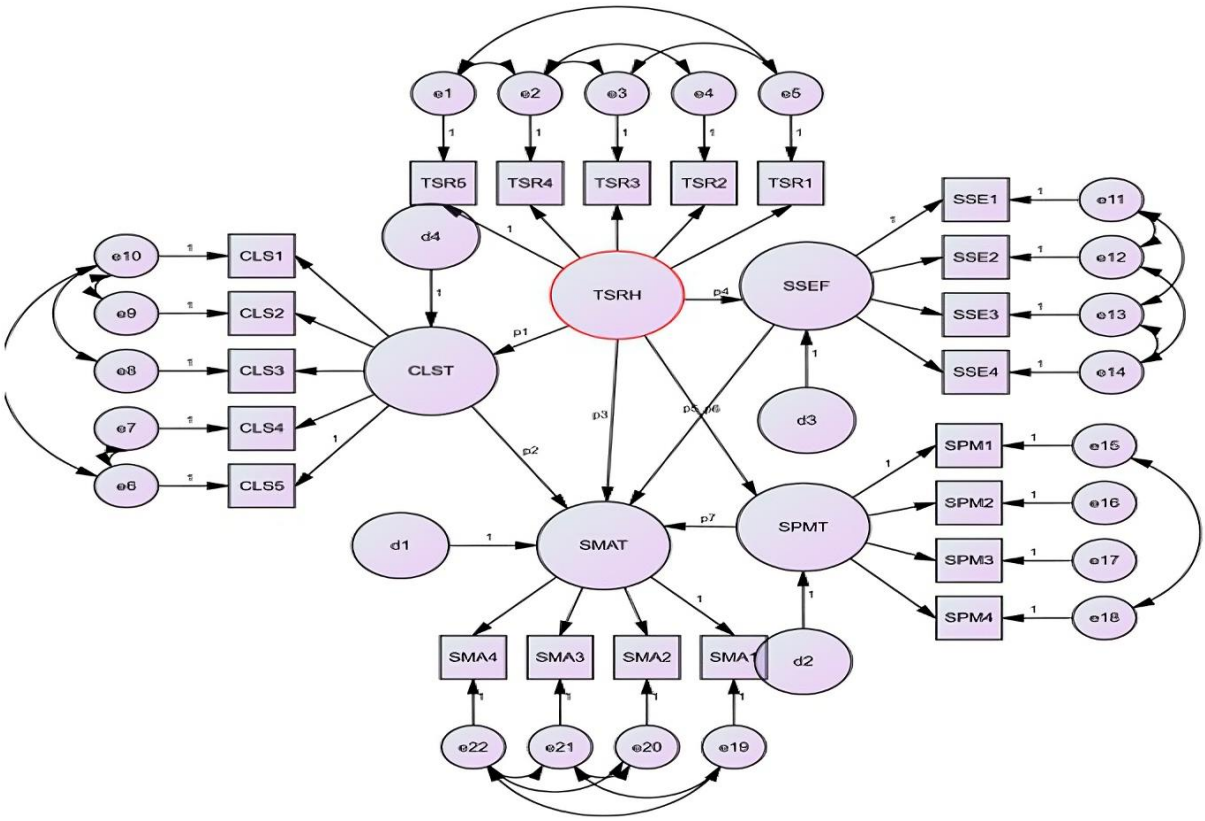

Figure 2. Path diagram (Source: Field Survey, 2022)

Hypothesis 1

H0. Teacher-student relationship will not significantly predict mathematics achievement.

H1. Teacher-student relationship will significantly predict mathematics achievement.

This research hypothesis is intended to determine whether teacher-student relationship would predict learner's mathematics achievement. **Table 6** shows the details of the results.

As indicated in **Table 6**, the direct effect of instructor-learner relationship on learners' mathematics achievement was statistically significant (B=-1.730, BCpCI 95% CI [-2.406, -1.010]). This implies that a unit increase in instructor-learner relationship would lead to 1.730 decrease in learner mathematics achievement. The result of this study suggests that the extent to which learners are related to their teachers can reduce their performance in the mathematics subject. Based on the result of this study, the null hypothesis, which stated "teacher-learner relationship will not significantly predict mathematics achievement." was rejected in favor of the alternate hypothesis (teacher-student relationship will significantly predict mathematics achievement.)

Table 6. Effect of teacher-student relationship on mathematics achievement (Source: Field Survey, 2022)

Hypothesis	Parameters	Estimate	BSE	BCpCI 95% CI		p-value
				LL	UL	
Teacher-student relationship→mathematics achievement	p3	-1.730	0.211	-2.406	-1.010	0.000

Note. CI: Confidence interval; LL: Lower limit; UL: Upper limit; BSE: Bootstrap standard error; BCpCI: Bias corrected percentile 95% CI for 2,000 bootstrap resamples of sample size of 320; & ***Significant p<.001

Table 7. Mediating effect of student perception as a link between teacher-student relationship & mathematics achievement

Effect	Hypothesis	Estimate	BSE	BCpCI 95%CI		p-value
				LL	UL	
Specific indirect effect (SIE 3)	TSRH→SPMT→SMAT	-0.279	0.055	-0.425	-0.192	0.000
Direct effect	TSRH→SMAT	-1.730	0.211	-2.406	-1.010	0.000
Total indirect effect	SIE1+SIE2+SIE3	-0.540	0.099	-0.787	-0.388	0.000
TE	TIE+p3	-2.270	0.391	-3.017	-1.525	0.002

Note. Source: Field Survey (2022); CI: Confidence interval; LL: Lower limit; UL: Upper limit; BSE: Bootstrap standard error; BCpCI: Bias corrected percentile 95% CI for 2,000 bootstrap resamples of sample size of 320; **Significant p<.005; TSRH: Teacher-student relationship; SPMT: Students' perception of mathematics; & SMAT: Student mathematics achievement

Table 8. Mediating effect of students' self-efficacy as a link between teacher-student relationship & mathematics achievement

Effect	Hypothesis	Estimate	BSE	BCpCI 95%CI		p-value
				LL	UL	
Specific indirect effect (SIE 3)	TSRH→SSEF→SMAT	-0.136	0.033	-0.217	-0.083	0.000
Direct effect	TSRH→SMAT	-1.730	0.211	-2.406	-1.010	0.000
Total indirect effect	SIE1+SIE2+SIE3	-0.540	0.099	-0.787	-0.388	0.000
TE	TIE+p3	-2.270	0.391	-3.017	-1.525	0.002

Note. Source: Field Survey (2022); CI: Confidence interval; LL: Lower limit; UL: Upper limit; BSE: Bootstrap standard error; BCpCI: Bias corrected percentile 95% CI for 2,000 bootstrap resamples of sample size of 320; **Significant p<.005; TSRH: Teacher-student relationship; SSEF: Students' self-efficacy; & SMAT: Student mathematics achievement

Hypothesis 2

H0. Students' perception of mathematics will not mediate the relationship between teacher-student relationship and mathematics achievement.

H1. Students' perception of mathematics will mediate the relationship between teacher-student relationship and mathematics achievement.

This research hypothesis is intended to determine whether students' perception of mathematics would mediate relationship between instructor-learner relationship and students mathematics achievement. **Table 7** shows the details of the results.

As presented in **Table 7**, the direct effect of instructor-learner relationship on mathematics achievement as statistically significant (B=-1.730, BCpCI 95% CI [-2.406, -1.010]). This implies that the closeness of students to their teachers can influence their mathematics achievement depending on the kind of relationship that exist between them. Similarly, the effect of instructor-student relationship on mathematics achievement was statistically significant (B=-0.279, BCpCI 95% CI [-0.425, -0.192]) when learners' perception of mathematics of mathematics was mediated in the relationship. This is evident in the specific indirect effect (see **Table 7**). The implication of this results is that learners' perception of mathematics explained the relationship between instructor-learner relationship and mathematics achievement. Since the direct effect of instructor-learner relationship on mathematics achievement is still significant, learners' perception of mathematics serves as a partial mediator between the relationship between instructor-learner relationship and mathematics achievement. Based on this result, the null hypothesis, which stated that learners' perception of mathematics will not meditate the relationship between instructor-learner relationship and learners' mathematics achievement was rejected in favor of the alternate hypothesis, which stated that "learners' perception will mediate the relationship between instructor-learner relationship and learners mathematics achievement".

Hypothesis 3

H0. Students' self-efficacy will not mediate the relationship between teacher-student relationship and mathematics achievement.

H1. Students' self-efficacy will mediate the relationship between teacher-student relationship and mathematics achievement.

This research hypothesis is intended to determine whether learners' self-efficacy of mathematics would mediate relationship between instructor-learner relationship and learners mathematics achievement. **Table 8** shows the details of the results.

As presented in **Table 8**, the direct effect of instructor-learner relationship on mathematics achievement as statistically significant (B=-1.730, BCpCI 95% CI [-2.406, -1.010]). This implies that the closeness of students to their instructors can influence their mathematics achievement depending on the kind of relationship that exist between them. Similarly, the effect of instructor-learner relationship on mathematics achievement was statistically significant (B= - 0.136, BCpCI 95% CI [-0.217, -0.083]) when learners' self-efficacy of mathematics was mediated in the relationship. This is evident in the specific indirect effect (see **Table 8**). The implication of this results is that learners 'self-efficacy of mathematics explained the relationship between instructor-learner

Table 9. Mediating effect of cooperative learning strategies as a link between teacher-student relationship & mathematics achievement (Source: Field Survey, 2022)

Effect	Hypothesis	Estimate	BSE	BCpCI 95%CI		p-value
				LL	UL	
Specific indirect effect (SIE 3)	TSRH→CLSF→SMAT	-0.125	0.030	-0.205	-0.078	0.000
Direct effect	TSRH→SMAT	-1.730	0.211	-2.406	-1.010	0.000
Total indirect effect	SIE1+SIE2+SIE3	-0.540	0.099	-0.787	-0.388	0.000
TE	TIE+p3	-2.270	0.391	-3.017	-1.525	0.002

Note. CI: Confidence interval; LL: Lower limit; UL: Upper limit; BSE: Bootstrap standard error; BCpCI: Bias corrected percentile 95% CI for 2,000 bootstrap resamples of sample size of 320; **Significant p<.005; TSRH: Teacher-student relationship; CLST: Cooperative learning strategies; & SMAT: Student mathematics achievement

relationship and mathematics achievement. Since the direct effect of instructor-learner relationship on mathematics achievement is still significant, learners' self-efficacy serves as a partial mediator between the relationship between instructor-learner relationship and mathematics achievement. Based on this result, the null hypothesis, which stated that "learners' self-efficacy will not meditate the relationship between instructor-learner relationship and learners' mathematics achievement" was rejected in favor of the alternate hypothesis, which stated that "learners' self-efficacy will mediate the relationship between instructor-learner relationship and learners mathematics achievement".

Hypothesis 4

H0. Cooperative learning strategies will not mediate the relationship between teacher-student relationship and mathematics achievement.

H1. Cooperative learning strategies will not mediate the relationship between teacher-student relationship and mathematics achievement.

This research hypothesis is intended to determine whether cooperative learning strategies would mediate the relationship between teacher-student relationship and students mathematics achievement. **Table 9** shows the details of the results.

As shown in **Table 9**, the direct effect of instructor-learner relationship on mathematics achievement as statistically significant (B=-1.730, BCpCI 95% CI [-2.406, -1.010]). This implies that the closeness of learners to their teachers can influence their mathematics achievement depending on the kind of relationship that exist between them. Similarly, the effect of teacher-learner relationship on mathematics achievement was statistically significant (B=-0.125, BCpCI 95% CI [-0.205, -0.078]) when cooperative learning strategies was mediated in the relationship. This is evident in the specific indirect effect (see **Table 9**). The implication of this results is that collaborative learning strategies explained the relationship between instructor-learner relationship and mathematics achievement. Since the direct effect of instructor-learner relationship on mathematics achievement is still significant, cooperative learning strategies serves as a partial mediator between the relationship between instructor-learner relationship and mathematics achievement. Based on this result, the null hypothesis, which stated that "cooperative learning strategies will not meditate the relationship between teacher-student relationship and learners' mathematics achievement" was rejected in favor of the alternate hypothesis, which stated that "cooperative learning strategies will mediate the relationship between teacher-student relationship and students mathematics achievement".

DISCUSSION

In terms of the impact of the instructor-learner relationship on mathematics achievement, the findings revealed that it has a considerable negative impact. The null hypothesis, "instructor-learner connection does not significantly affect mathematics achievement," was rejected as a result of these findings. The findings suggest that the degree to which learners connect with their instructors will decide the type of impact it has on their arithmetic achievement. This suggests that the relationship between instructors and learners has a detrimental impact on learners' math performance. The current study's findings are consistent with those of a number of other research. According to a study by Pianta. (1999) on the instructor-learner relationship and mathematics achievement, learners who have a positive perception of their instructor and instructors who are willing to improve their careers have higher mathematics achievement. Hughes (2007) discovered in his research that the types of relationships instructors form with their learners have a significant impact on their academic performance. Also, according to Wasike (2013), a strong instructor-learner relationship may be the cornerstone that allows different views to operate successfully together. Despite the fact that several research studies have found a link between instructor-learner relationships and learners' mathematics achievement, the current study differs from one conducted by Appiah et al. (2022) The findings of that study suggest that the instructor-learner connection has no effect on mathematics achievement. That is to say, the type of relationship that exists between instructors and their learners has no bearing on their mathematical achievement.

According to Mensah and Koomson (2020) research, the type of relationship instructors has with their learners can sometimes be disincentive to learning. This new study agrees with Mensah and Koomson (2020) findings. According to the findings, the degree of instructors' closeness with learners can lead to learners paying less attention to their studies. They conducted an interactive discussion with learners as part of their research, and some participants stated that some instructors have a special relationship with some learners, to the point where they award marks to them even when they do not participate in class exercises or write exams. This discourages the learner from learning. Also, some instructors have unhealthily relationship with their learners, which has a negative impact on their academic achievement. This is because whenever the instructor stands in front of the class, the

learner may think to themselves, "Oh, he'll just give me marks, so why should I pay attention to him?" Furthermore, when instructors criticize learners, they feel depressed or useless, and as a result, they put less effort into their academic work. When this attitude toward learners persists, it has a negative impact on their academic achievement. Furthermore, when instructors are harsh on learners, it might have a negative impact on their academic achievement (Mensah & Koomson, 2020).

It is obvious from the responses above that when instructor-learner relationships become distorted, the impact on learners' academic engagement and accomplishment is negative. According to the findings, instructors should try to intentionally create strong relationships with learners as part of their efforts to improve learners' academic achievement. This could be accomplished by expressing worries about learners' academic progress as well as other challenges that they face at home. Learners would feel accepted and driven to cooperate and enhance their academic performance as a result of this.

According to the findings of this study's sub-topical problem, learners' perceptions of mathematics explain the association between instructor-learner relationships and mathematical achievement. That is, the impact of the instructor-learner interaction on mathematics achievement can be influenced in part by learners' perceptions of mathematics subjects. The null hypothesis, "Learners' view of mathematics does not significantly affect the association between instructor-learner interaction and mathematical achievement," was rejected as a result of these findings. According to the findings, learners' perceptions of mathematics were partially mediating the relationship between the instructor-learner relationship and math achievement. This is because, even with the mediating variable present, the direct influence of the instructor-learner relationship on mathematical achievement was still considerable. The direct effect suggests a negative association between mathematics and the instructor-learner interaction. The indirect effect of the instructor-learner connection on mathematics achievement through learners' view of mathematics was equally negative after the mediating variable was introduced, however the effect was not as severe as the direct effect. This finding suggests that, while the instructor-learner relationship negatively predicts mathematics achievement, as long as learners maintain a positive attitude toward mathematics, no matter how unhealthy the instructor-learner relationship is, it will not have a negative impact on their mathematics achievement.

According to the findings, the indirect influence of the instructor-learner connection on mathematics achievement via learners' self-efficacy is negative. The null hypothesis, "learners' self-efficacy does not significantly mediate the association between instructor-learner interaction and mathematical achievement," was rejected as a result of these findings. Learners' self-efficacy mediates or explains the association between instructor-learner interaction and mathematical achievement, according to the findings of this study. That is, how learners viewed their self-confidence in dealing with mathematics problems can predict the impact of the instructor-learner relationship on mathematics achievement. Learners' self-efficacy was found to be partially mediating the association between instructor-learner interaction and mathematical achievement, according to the findings of the study. This is because, even with the mediating variable present, the direct influence of the instructor-learner relationship on mathematical achievement was still considerable. The direct effect suggests a negative association between mathematics achievement and the instructor-learner interaction. The indirect effect of the instructor-learner connection on mathematics achievement through learners' self-efficacy was similarly revealing a negative link once the mediating variable was introduced, however the significant effect was not as high as the direct effect. Despite the fact that there is a negative association between instructor-learner relationships and mathematics accomplishment, the outcomes of this study suggest that if learners have a high efficacy for mathematics and not over confidence with all sorts of mistakes and errors when dealing with mathematical problem, they will be able to receive better grades in the mathematics subject.

The current study's findings show that collaborative learning has a statistically significant mediation influence on the association between instructor-learner relationship and mathematics achievement. The null hypothesis, "Collaborative learning strategies does not significantly mediate the association between instructor-learner interaction and mathematics achievement," was thus rejected. The findings show that collaborative learning mediates the link between the dependent and independent variables to some extent. When both the direct and indirect effects of the independent and dependent variables are significant, partial mediation occurs. The direct and indirect effects of the instructor-learner interaction on mathematics achievement were statistically significant, just as they were in this study. The direct effect of the instructor-learner relationship negatively predicts mathematics achievement in the presence of collaborative learning mediating the link between instructor-learner relationship and mathematics achievement. The direct effect of collaborative learning practices on mathematics achievement is positive. Surprisingly, there was a significant negative indirect effect between the instructor-learner connection and mathematics achievement when collaborative learning mediates the link. The indirect effect of the instructor-learner connection on mathematics achievement through cooperative learning techniques was similarly revealing a negative link once the mediating variable was introduced, however the significant effect was not as high as the direct effect. This gives an indication that, no matter the kind relationship that exist between instructors and their learners, if appropriate collaborative learning techniques are being implemented, learners are more likely to excel in the mathematics subject. That is to say, a strained instructor-learner relationship, as well as inefficient collaborative learning practices, can all contribute to lower math achievement. Appropriate approaches, such as instructors creating good relationship-building habits with their learners and applying effective collaborative learning strategies, can be implemented to help learners improve their mathematical achievement.

CONCLUSIONS AND RECOMMENDATIONS

Based on the findings, it can be concluded that too close relationship between teachers and their learners may cause reduced attention to studies on the part of the learners. This situation may be as results of unhealthy relationships that exist between teachers and their learners. So, when this happens, some teachers try to please such learners, by awarding marks to such learners even when they do not perform class exercises or even write examination. This makes the learner feel lazy to learn. Also, because

of the unhealthy relationship that exist between them, anytime the teacher stands in front of the class, the learner may say “oh after all, he will gift me marks and so why should I pay attention to him” and this will affect the mathematics achievement of such learners. There are also some learners who do not agree with such unhealthy proposal, and due to that some teachers tries to disgrace and condemn such learners. This will make them feel miserable or useless and therefore do not put much effort in their academic work anymore. When this attitude toward learners persists, it has a negative impact on their academic achievement. Again, very close association between learners and instructors can depreciates the mathematics accomplishment of learners. This is of the fact that, when learners are close with their instructors, they take them as their peers, so the concentration during instructional hours becomes limited. Based on the findings, it is proposed that teachers should try to intentionally create strong relationships with learners as part of their efforts to improve learners’ academic work. This could be accomplished by expressing worries about learners’ academic work as well as other challenges that they face at home and refraining from forming harmful relationships with them. Learners would feel accepted and driven to cooperate and enhance their academic performance as a result of this.

Moreover, the results of this study give enough facts to conclude that despites the negative influence of teacher-learners relationship on mathematics achievement, learners’ own perception about mathematics and the collaborative learning techniques adopted by the instructors can intervein and improve the mathematics achievement of the learners. This is because learners’ own perception about mathematics and collaborative learning techniques were having a positive influence on mathematics achievement. So, mediating or explaining the relationship between the closeness of learners to their teachers and mathematics achievement will help reduce the negative direct influence of teacher-learner relation on mathematics achievement of learners, thereby improving it alongside. The finding of the study suggests that, as teachers are building good relationship with their learners, much attention should also be emphasized on their perception about the subject and the efficacy of learners toward the subject for effective mathematics instruction.

Lastly, the findings of the study came out with a conclusion that despite the negative direct effect of teacher-learner relationship and students’ self-efficacy on mathematics achievement, when students’ self-efficacy intervenes the connection between teacher-learner relationship and mathematics achievement, learners are likely to perform well in the mathematics subject. This indicates that as teachers try to cultivate and exhibit good relationship with their learners, effective students’ self - confidence without errors when dealing with mathematical problem can also accelerate the mathematics achievement of the learners.

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APPENDIX A: QUESTIONNAIRES FOR STUDENTS

You are kindly requested to read through the items and responses will be treated as confidential and will be used only for academic purposes. Thanks for taking time to help with this research.

Section A: Bio Data

Please tick [√], where appropriate.

1. **Gender**: Male [ ], Female [ ]
2. **Age**: 13-15 years [ ], 16-18 years [ ], 19-21 years [ ], 22-25 years [ ], 26 and above [ ]
3. **Religion**: Christian [ ], Muslim [ ], Traditional worshiper [ ], Others [ ]: Specify……..
4. **Program/option**: Science [ ], General arts [ ], Business [ ], Home economics [ ], Visual arts [ ], Agricultural studies [ ]
5. **Track**: Gold [ ], Green [ ], Single [ ]
6. **Class:** Form 1 [ ], Form 2 [ ], Form 3 [ ]

Section B: Students' Self- Efficacy

Instructions: This section has statements that you are to decide carefully whether you strongly agree (**SA**), agree (**A**), unsure (**U**), disagree (**D**), or strongly disagree (**SD**). Select by a tick [√] against each statement depending on what you think (**Table A1**).

Table A1.

No	Statement	SA	A	U	D	SD
1	I am confident with mathematics.					
2	I know how to attack difficult questions in mathematics.					
3	I believe I am the type of person who is good at mathematics.					
4	I can confidently help my friends to solve their mathematics problems.					
5	I get high scores in mathematics.					
6	I believe I am a mathematics person.					
7	I feel confident to ask questions during mathematics lessons.					
8	I make myself prepared for mathematics lessons.					
9	I get frustrated when the discussion is interrupted, or the teacher is absent.					
10	I feel that I will be able to do well in future mathematics courses.					

Section C: Teacher-Students' Relationship

Instructions: This section has statements that you are to decide carefully whether you strongly agree (**SA**), agree (**A**), unsure (**U**), disagree (**D**), or strongly disagree (**SD**). Select by a tick [√] against each statement depending on what you think (**Table A2**).

Table A2.

No	My mathematics teacher …	SA	A	U	D	SD
1	Has mastery of the subject matter.					
2	Imposes proper discipline and is not lenient in following the prescribed rules.					
3	Presents the information in a way that is easy to understand.					
4	Imposes proper discipline and is not lenient in following the prescribed rules.					
5	Uses various strategies teaching aids /device and techniques in presenting lessons.					
6	Has a good relationship with the students and teachers.					
7	Has an appealing personality with good sense of humor.					
8	Is open to suggestions and opinions and is worthy of praise.					
9	Shows interest in all students irrespective your ability.					
10	Motivate students through aspiring teaching.					

Section D: Students Perception of Mathematics

Instructions: This section has statements that you are to decide carefully whether you strongly agree (**SA**), agree (**A**), unsure (**U**), disagree (**D**), or strongly disagree (**SD**). Select by a tick [√] against each statement depending on what you think (**Table A3**).

Table A3.

No	Statemets	SA	A	U	D	SD
1	I think that mathematics is useful in life.					
2	I enjoy studying mathematics.					
3	I rate mathematics high to all the other core subject.					
4	I would like to pursue mathematics in the tertiary level.					
5	I have interest in mathematics.					
6	I prefer mathematics to other subjects.					
7	I perceive mathematics to be a difficult subject.					
8	Mathematics is for students with high ability.					
9	I am one of those people who just doest understand mathematics.					
10	I am proud of my abilities in mathematics.					

Section E: Cooperative Learning Strategies

Instructions: This section has statements that you are to decide carefully whether you strongly agree (**SA**), agree (**A**), unsure (**U**), disagree (**D**), or strongly disagree (**SD**). Select by a tick [√] against each statement depending on what you think (**Table A4**).

Table A4.

No	Statemets	SA	A	U	D	SD
1	When we work together in small groups, we try to make sure that everyone in the group learns the assigned material.					
2	When we work together in small groups, we all receive the same grade.					
3	In class we learn more when we work together.					
4	I should get along with other students better than I do.					
5	I like to participate in team.					
6	I would rather work in teams than on my own.					
7	When we work in small groups, our grade depends on how much all members learn.					
8	When we work together in small groups, teacher divides up material so that everyone has a part, & everyone has to share.					
9	When we work together in small groups, we cannot complete an assignment unless everyone contributes.					

Section F: Students' Mathematics Achievement

Instructions: This section has statements that you are to decide carefully whether you strongly agree (**SA**), agree (**A**), unsure (**U**), disagree (**D**), or strongly disagree (**SD**). Select by a tick [√] against each statement depending on what you think (**Table A5**).

Table A5.

No	Statemets	SA	A	U	D	SD
1	Mathematics makes me think fast.					
2	Mathematics is more enthusiastically for me than a significant number of my schoolmates.					
3	I get good marks in mathematics.					
4	I usually do well in mathematics.					
5	Mathematics helps me to understand other subjects.					
6	Mathematics is easy subject to pass.					
7	I feel happy when answering mathematics questions.					
8	I can perform excellently well if I do not give up.					
9	My present knowledge in mathematics is high					