Assessing Academic Achievement and Attitude of High School Students towards Geometry: A Case of Southern Tigray Zone

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Abstract

The purpose of this study was to explore the academic achievement and attitude of high school students in geometry in southern Tigray zone. The study adopted a descriptive survey method. The target schools were selected using simple random sampling method. From the selected high schools, whole classrooms were selected using cluster sampling method. A sample of 299 grade ten students were included in this study. The research was done based on qualitative and quantitative data. The data collection tools were open ended questionnaire, attitude items, students' achievement test, and focus group discussion. A five-point Likert scale was used to measure students' attitude towards geometry. Cronbach's alpha was used to check the internal consistency of the attitude items and a value of 0.7263 reliability coefficient was found. Kuder-Richardson Formula 20 was applied and a value of 0.6238 reliability coefficient of the achievement test was found. Moreover, the average difficulty level of the achievement test was 37.02 percent and the average discrimination power was 43 percent. The findings of the study showed that poor students' achievement and negative attitude towards learning geometry. Based on the results of the study, different recommendations are suggested in order to minimize the existed problems in the study area.

*Keywords***:** *Academic Achievement, Geometry, High school students, Students' Attitude*

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Introduction

Geometry is one of the classical disciplines of mathematics that has wide practical uses in the day to day activities of human beings. It develops students' critical thinking, logical reasoning, and ability to solve real world problems (Jones & Mooney, 2003; Presmeg, 2006). It is also helpful to acquire abilities such as making new discoveries, analyzing problems and making connections between mathematics and real-life situations (Bindak, 2004). In line with this, Sudhir (2003) indicated that geometry is frequently used to model what we call the "real world" and has many applications in solving practical problems. For example, animations, video games, and designing are created using geometric knowledge and skills.

Understanding the various uses of geometry, Ethiopia incorporated geometry as part of the mathematics curriculum to enable students to understand characteristics of two- and three-dimensional geometric shapes, develop mathematical arguments about geometric relationships, specify locations and describe spatial relationships using coordinate geometry and other representational systems, and use visualization, spatial reasoning, and geometric modelling to solve problems (MoE, 2009). In this regard, teaching geometry so that students learn it meaningfully requires an understanding of how students construct their knowledge of various experiences in school. Moreover, mathematics teachers are expected to generate multiple methods of proof of theorems and corollaries in order to demonstrate the power of different methodologies such as discovery, inquiry, and problem-solving methods (Dawson, 2006). This is because effective utilization of these methods increases students' understanding of geometry and their academic achievement. In line with this, Sudhir (2003) argued that students should learn geometry based on the psychological principle of "learning by doing." Students are allowed to observe and handle objects, figures, shapes, and learn their names. It is through practical work that students grasp fundamental ideas of geometry and improve their achievement.

On top of the above points, the attitude of students can influence their learning process as well as their academic achievement. In this regard, it is important to see the definition of attitude and how it affects students' academic achievement. Phillips (2003) defined attitude as a multi-faceted psychological construct based on an individual's feelings, beliefs and values. Likewise, Thompson (2003) described attitude as a learned pattern of manners that is developed through one's environment. Attitude towards mathematics include liking, enjoying, and interest in mathematics, or the opposite, and at worst mathematics phobia (Ernest, 1989). In particular, Utley (2004) defined attitude towards geometry as set of beliefs focusing on geometry that predisposes a person to respond in a certain way.

To this end, several researchers have affirmed that attitude is a key factor in all endeavors undertaken to understand and explain variability in student academic achievement (Singh, Granville, & Dika, 2002). Most research on students` attitude pointed out that attitude plays a crucial role in learning and achievement of mathematics (Zan & Di Martino, 2007). Hence it determines the students' success in the subject. It determines their ability and willingness to learn the subject, work on a variety of assigned tasks and their persistence in the tasks available. Moreover, Olatoye and Agbatogun (2009) found out that students' attitude towards learning geometry had a direct effect on student achievement in the topic. Similarly, if students have positive attitude towards geometry, they are expected to like geometry, participate in the classroom activities and to be high achievers in geometry (Ünlü, Avcu, & Avcu, 2010).

Despite the importance of geometry and its recognition among the mathematics topics, it is evident that large number of students still have negative attitude and low achievement in geometry (Adesokan, 2002). De Villiers (2009) also argued that the direct teaching of geometry definitions with no emphasis on the underlining process of defining has often been criticized by mathematicians as students memorize definitions of geometry mechanically without any understanding. Moreover, aims of teaching geometry are generally ignored by mathematics teachers; demonstrative geometry is started without any concrete base; mathematics teachers use the same method for all types of students without consideration of the individual differences. Lack of understanding of geometrical concepts and vocabulary in the beginning give the impression to students that geometry is difficult topic and finally affect their academic achievement (Singh et al., 2002). To this end, the National Learning Assessment in Ethiopia showed that grade ten national mean score of all subjects was 36 percent which is less than the 50 percent achievement level set by Ministry of Education. Moreover, the mean score of grade ten mathematics was 34.7 percent. There was also gender difference in grade ten mathematics achievement. The mean score of male students was 37.4 percent while that of female students was 30.9 percent (Woldetsadik, 2013).

This result clearly indicates low students' achievement in mathematics and hence in geometry. Cognizant of the above facts, the researchers were motivated to conduct this research on southern Tigray zone to provide answers to the following questions.

What is the attitude of high school students towards learning geometry?

Do high school students have the required achievement level in geometry?

What is the relationship between students' attitude and their achievement in geometry?

Significance of the Study

The findings of this study will help in providing information for high school students, mathematics teachers, school directors, school community, parents, and Tigray Region. Besides, the results of the study may give an insight for the Education Bureau about the current achievement level and attitude of grade ten students towards learning geometry. It will also serve as a reference for policy makers, curriculum developers, and encourage other researchers to do more research on the issue.

Objectives

The broad objective of this study was to assess academic achievement and attitude of high school students in Geometry in southern Tigray zone. Thus, the specific objectives were to:

- ✓ explore the attitude of high school students towards learning geometry.
- ✓ assess achievement in geometry as prescribed in the mathematics curriculum.
- ✓ examine the relationship between students' attitude and their achievement in geometry.

Methodology

Research Methodology

This study focused on assessing academic achievement and attitude of high school students in geometry in southern Tigray zone. A descriptive survey method was used to justify the current practice and make judgment about the event in the study area.

Sources of Data

This study used only primary data. The data collected from grade ten students through open ended questionnaire, attitude items, achievement test, and focus group discussion.

Sample and Sampling Procedures

According to the Tigray Regional State Education Bureau (TRSEB, 2015/16), there were 8 Wereda and 25 public high schools in the study area. Of these high schools, four schools were selected using simple random sampling method and thus whole classrooms were considered as clusters. Consequently, eight classrooms were selected using simple random sampling method. All the students in the selected classrooms were considered as a sample for the purpose of this study. To this end, from a population of 5378 grade ten students, 299 students enrolled during the 2016/17 school year were selected as participant of this study.

Data Collection Instruments and Procedures

Questionnaire, achievement test, and focus group discussion were used as main tools of data collection. The questionnaire was developed to measure students attitude towards geometry. The Questionnaire was prepared in a five-point Likert scale (Strongly agree = 5, Agree = 4, Undecided = 3, Disagree = 2, and Strongly disagree = 1). The items were composed of positive and negative items and thus negative items were reversed while data were encoded into the data analysis package. The internal consistency of items included in the questionnaire were checked using Cronbach's alpha and the value was found to be 0.7263. This value indicated an acceptable internal consistency of the items.

Moreover, the achievement test was designed to measure grade 10 students' level of achievement in geometry based on the learning competencies set by the Federal Democratic Republic Government of Ethiopia (MoE, 2009). For this purpose, thirty multiple choice questions were prepared from grade ten mathematics syllabus, teacher's guide, and students' textbook. The test included all portions of geometry in grade nine and grade ten mathematics students' textbooks. Students' test result was recorded as right and wrong. Then after, their values were coded as "1" for right answer and "0" for wrong answer. The reliability of the achievement test was checked by Kuder-Richardson Formula 20 (KR-20) and the reliability coefficient of the test items was found to be 0.6238. The values of KR-20 ranges from 0 to 1

and greater than 0.5 is an acceptable value in teacher made test and the higher the value is always the better (McGahee & Ball, 2009).

Moreover, item difficulty and item discrimination power of the test were calculated to see its relevance. Item difficulty expresses the proportion of students who answered the item correctly in relation to the total students who took the test. Kehoe, as cited in (McDonald, 2017) showed that the desired item difficulty value of a test ranges from 0.3 to 0.8. In line with this, the item discrimination describes how well the item serves to discriminate between students with higher and lower levels of knowledge. As a general rule, item discrimination values between 20 percent and 80 percent are considered to be desirable (McGahee & Ball, 2009). In this regard, the average difficulty level of the achievement test was 37.02 percent and its average discrimination power was taken to be 43 percent. In addition to the questionnaire and tests, focus group discussion was also made with selected grade ten students. The focused group discussion was undertaken to collect data that substantiate the information obtained through questionnaire and tests.

Data Analysis

Percentage, rank-order, mean values, Pearson correlation, and independent t-test were used to analyze and interpret the quantitative data through Stata version 12. Data collected through questionnaire was analyzed through mean and independent sample t-test. In so doing, each response associated with five-point Likert scale was calculated by summing the point values given for each attitude items. Then, the scores were categorized into above and below mean scores. Scores falling above the mean would indicate positive attitude towards learning geometry and vice versa. An independent t-test was used to determine if there was a statistically significant difference between mean attitude scores of male and female students in geometry. Moreover, the mean score of students' achievement test was analyzed using an independent t-test. The independent t-test was employed to determine whether there exists a statistically significant difference between mean achievement scores of males and females in geometry.

Furthermore, Pearson correlation was employed to determine the type and the strength of relationship between the students' achievement and attitude. Finally, an independent sample t-test was employed to see the differences between male and female students in terms of their achievement in geometry and attitude towards learning geometry. Data collected through the focused group discussion was analyzed qualitatively. In so doing, the researchers have transcribed the data collected through the focused group discussions and thus the trends that support or explain the findings obtained through the questionnaire and tests were presented accordingly.

Results

This part presents results of the data collected through different tools and sources. The collected data was analyzed through quantitative and qualitative methods. Descriptive summary statistics and statistical tests were carried out to analyze the quantitative data. In the case of qualitative methods, similar information was grouped into similar themes for ease of analysis and making conclusion. In

order to answer each of the research questions, the results were organized in the following three major themes.

Students' Attitude towards Learning Geometry

Table 1: Students' Attitude Mean Score towards Learning Geometry

Students' Attitude Score	Frequency	Percent	Cum. frequency
Above mean score	141	47.16	47.16
Below mean score	158	52.84	100
Total	299	100	

Table 1 presents students' attitude towards learning geometry. Accordingly, the table implies that 52.84 percent of the respondents seems to have negative attitude towards learning geometry as their attitude score was below the mean score. However, the remaining 47.16 percent of the respondents seems to have positive attitude towards learning geometry as their attitude score was above the mean score. To investigate whether males and females differ on their attitude towards learning geometry, the difference between the two groups is tested using an independent t-test here below (see table 2 below).

Table 2: Comparison of Grade Ten Students' Attitude towards Learning Geometry

Groups	*N*	*Mean*	*Sd*	*t*	*df*	*p*
Male	158	66.47	8.90	-4.01	297	0.00
Female	141	46.42	7.69			

The result in Table 2 shows attitude differences between male and female students towards the learning Geometry. The table implies that male students have better attitude towards geometry than their female counter parts and the differences between the two groups seem to be statistically significant (t = -4.01, df = 297, p = 0.000). That is, the average attitude score for female students (46.42) were significantly lower than the average score (66.47) for male students.

2. Students' Achievement Test Results

The second research question was intended to assess grade ten students' achievement in geometry based on the minimum learning competency in grade ten mathematics curriculum stated by the Federal Democratic Republic of Ethiopia (MoE, 2009).

Table 3: Comparison of Students on a Geometry Achievement Test

	Number of respondents (N = 299)			
	Above cut-off scores (50%)		Below cut-off scores (50%)	
Sex of respondents	Count	%	Count	%
Male	49	16.39	109	36.45
Female	23	7.69	118	39.47
Total	72	24.08	227	75.92

This result showed that only 24.08 percent of the total students scored above the cut-off scores while majority of the students (75.92%) scored below it. The result also indicated that 16.39 percent male and 7.69 percent female students scored above 50 percent in the achievement test.

Table 4: Students' Mean Score in Geometry Achievement Test

Variable	N	M	SD	*Min*	*Max*
Geometry Achievement Test	299	37.00	13.60	10	76.66

Table 4 showed that the descriptive summary statistics of students' achievement score in geometry. The students' mean score of the achievement test was 37.00 with 13.6 standard deviation values. The lowest and the highest students' scores were 10 and 76.66 respectively. The overall result showed that students' poor achievement score in geometry. Moreover, an independent t-test was used to compare mean score of geometry achievement test between male and female students.

Table 5: Comparison of Students' Mean Score in Geometry Achievement Test

Groups	Mean	SD	*t*	*df*	*p*
Males	39.28	14.26	-3.10	297	0.001
Females	34.46	12.39			

The result in Table 5 indicated that males were significantly different from females on geometry achievement test (t = -3.10, df = 297, p = 0.001). That means the average geometry achievement score for female students (34.46) is statistically lower than the score (39.28) for males. A look on the table, the difference between male students' mean score in geometry achievement test and that of female students was 4.82. In addition to the achievement test, students were asked to rank geometry concepts such as corollaries, proving corollaries, theorems, proving theorems, construction of geometric figures, and definitions based on their difficulty to understand effectively.

Table 6: Rank of Geometry Concepts Based on Level of Difficulty to Understand

	Sex of respondents			
Geometry Concepts	Female	Male	Total	Rank
Proving corollaries	87 (61.7%)	105 (66.46%)	192 (64.21%)	1
Corollaries	80 (56.74%)	96 (60.76%)	176 (58.86%)	2
Proving theorems	74 (52.48%)	90 (56.96%)	164 (54.85%)	3
Construction	77 (54.61%)	80 (50.63%)	157 (52.51%)	4
Theorems	47 (33.33%)	66 (41.77%)	113 (37.79%)	5
Definitions	59 (41.84%)	37 (23.42%)	96 (32.11%)	6
Total cases	141	158	299	

In Table 6, the first rank indicated that the most difficult concept to understand while the last rank showed relatively the easiest one. In this regard, proving corollaries, corollaries and proving theorems were relatively difficult concepts to understand than the other concepts. Moreover, the result of the focus group discussion showed that students did not involve in numerous activities and questions to make discoveries about geometry concepts. They did not engage to observe and handle concrete objects, figures, and different geometric shapes. Lecture method was the most widely used by their mathematics teachers in the teaching and learning process of geometry. Their schools had shortage of appropriate geometry models and mathematical sets.

3. Relationship between Students' Attitude and their Achievement in Geometry.

The correlation between students' attitude towards learning geometry and their achievement in geometry was checked through Pearson correlation (r). The linear relationship between the two variables were checked using the scatter plot. The variables were normality distributed and there were no significant outliers.

Table 7: Correlation between Students' Attitude towards Geometry and their Achievement (n=299)

Variable	*Attitude*	*Achievement*	*sig*
Attitude	1.00	0.367	0.00
Achievement	0.367	1.00	0.00

*. Correlation is significant at the 0.05 level (2-tailed).

Table 7 summarizes the result of Pearson correlation (r) analysis. The result showed that a statistically significant association between students' attitude towards learning geometry and their achievement in geometry. The Pearson correlation (r) statistic was 0.3673 with $p < 0.05$. The positive correlation implies that students who have positive attitude towards learning geometry had a tendency to have high achievement result in geometry and vice versa.

Discussion

This part presents detail discussion of the results obtained from the study in accordance to the basic research questions. This research tried to investigate the academic achievement and attitude of high school students towards geometry. Regarding students' attitude towards learning geometry, Wigfield and Meece (1988) showed that learning is highly related to attitude; what is learned depends on the attitude of the learner. Students' attitude towards the teacher, the school, and various subjects are primarily important in the teaching-learning process. In this study, about 52.84 percent of the respondents showed their negative attitude towards learning geometry as their attitude score was below the mean score while 47.16 percent of the respondents revealed their positive attitude. That means, a large portion of grade ten students were less valuing their learning of geometry. In comparison to their gender, the independent t-test showed that males were found to have higher positive attitude than their females' counter parts. That is, the average attitude score for male students were statistically significant than that of female students. In line with this finding, some studies (Asnate, 2012 & Eshun, 2004) had reported similar results.

Regarding to the achievement test result, the finding of this study showed that only 24.08 percent of the total students scored above 50 percent. The mean score of the students was 37 percent. Moreover, results of the questionnaire and the focus group discussion showed that students' activity and participation was limited to listening and writing. Students could not properly understand geometry concepts such as corollaries, theorems, and construction of geometric figures. This result is consistent with the finding of National Learning Assessment in Ethiopia (Woldetsadik, 2013).

In the same vein, the National Learning Assessment revealed that the mean score of grade ten mathematics was 34.7 percent which was less than the achievement level set by Ministry of Education. The main purpose of grade ten mathematics curriculum was to enable all students to acquire high-level of learning skills, critical thinking, and problem-solving ability (MoE, 2009). Moreover, it helps students to develop their knowledge on fundamental mathematical notions, theorems, rules, procedures, and works continuously towards developing the students' mathematical capabilities. It encourages students to think independently in solving mathematical problems. Students understanding of the need for proofs have to be deepened by encouraging them to carry out simple proofs independently (MoE, 2009). Unlike the above facts, the finding of this study showed that students' poor achievement in geometry. That means, the students did not acquire the basic knowledge and skills of geometry as per the demand of the mathematics curriculum.

As to the relationship between students' geometry achievement and their attitude towards learning geometry, the finding of this study showed that a medium positive significant correlation. In consistence to this finding, the results obtained by (Nicolaidou & Philippou, 2003) and Papanastasiou (2002)

revealed significant correlations between students' attitude and their achievement in mathematics. In this regard, there is a general belief that children learn more effectively when they are interested in what they learn, and they will achieve better in mathematics if they like mathematics (Ma and Kishor, 1997). Similarly, Recep Bindak (2004) suggested that if students have positive attitude towards geometry, they are expected to like geometry, participate in the classroom activities and to be high achievers in geometry. Mato and de la Torre (2009) in a study with secondary school students also showed that those with better academic achievement have more positive attitude regarding mathematics than those with poorer academic achievement.

Conclusion and Implications

From the findings of this study, we can conclude that there is a wide gap between the demand of grade ten mathematics curriculum and the actual students' geometry achievement and attitude towards learning geometry in the study area. This can be seen in various ways. The curriculum demands students to display a positive attitude towards their own education by showing a willingness to play an active role and contribute in lessons and practical activities. However, the finding of the study showed students' negative attitude towards learning geometry and poor geometry achievement result. There was also gender disparity in their geometry achievement result and attitude towards learning geometry. Besides, students had difficulty in understanding the fundamental concepts of geometry such as proving corollaries, proving theorems, and construction of geometric figures. Thus, these problems definitely have significant effect in students' attitude towards learning geometry and their achievement in geometry.

Therefore, in order to fill these gaps, it will be better if students are nurtured with the applications of geometry so that they could develop positive intentions into the content of geometry. It is also important to develop effective strategies that can improve both students' attitude towards learning geometry and achievement throughout their schooling. Engaging students in various interesting geometry lessons can also facilitate effective learning and thereby improve their achievement. Moreover, the gender gaps observed in geometry achievement and attitude towards learning geometry can be narrowed by creating conducive competitive learning environment such as letting them coordinate, exchange their knowledge from one another in geometry teaching and learning process, giving additional tutorial classes by identifying the difficult concepts and giving fair and equal treatments in the teaching and learning process

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