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Difficulties in Learning Geometry Component in Mathematics and Active-Based Learning Methods to Overcome the Difficulties

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Abstract
Learning Geometry emphasizes exploring different representations such as virtual manipulatives, written math formulas, and verbal explanations, which help students build mathematical concepts and develop critical thinking. Student's performance in G.C.E (O/L) examination in Sri Lanka for the Geometry component is at a very low level. This study aims to identify the difficulties of learning Geometry at Grade 11 and provide some suggestions for overcoming these issues using active based learning.
This study uses a quantitative survey, a diagnostic test, and a teaching experiment conducted with randomly selected three hundred students from grade 11students and 35 mathematics teachers from 42 schools in Vadamarachchi education zone Sri Lanka. Questionnaires were used to collect data from the teachers and the students. The diagnostic test was also used to collect data from the students. Forty students were selected for the teaching experiment based on diagnostic test results and divided into two equally talented groups using a rubric. The teaching experiment was done to test the effectiveness of activity-based teaching methods in teaching Geometry. Findings from the study revealed that students had greater difficulties in learning Geometry such as drawing diagrams for a given geometric problem and applying more than one theorem to solve a given Geometry problem. Furthermore, Students' disinterest in the Geometry component and their family background affects their Geometry learning. Additionally, results from the teaching experiment indicate that the student-based learning approaches are more effective than conventional methods for teaching Geometry.
Keywords: Active-based Learning, Conventional Teaching Methods, Difficulties, Geometry Component, Quantitative Survey, Teaching Experiment

Introduction

Geometry is used in various fields such as Astronomy, Architecture, Engineering and Physics. For example, a skilled diamond cutter can transform a dull lump of diamond rack into beautiful gems. Further, carpenters used this geometrical knowledge in their profession called joinery. According to (Biber, 2013), "geometry is a branch of mathematics concerned with point, straight line, plane figures, space, spatial figures, and the relations between them". The word 'Geometry' comes from the two ancient Greek words, "Geo" (earth) and "metria" (measure). The origins of Geometry are from very ancient

Egyptian and Babylonian civilizations. They used practical knowledge of geometry through surveying lands, constructing huge dams and buildings such as pyramids with astonishing shapes and structures.

In Sri Lanka, at the most three decades back, Geometry component had been included as a separate paper in mathematics for G.C.E. (O/L) Examination. Student had to study many theorems and their proof. Therefore, student's mathematics ability was measured through his/her knowledge and interest in Geometry.Now in Sri Lanka, students show low performance in Geometry part in Mathematics paper in G.C.E. (O/L) Examination (National evaluation reports in 2011, 2012 and 2013) even though mathematics paper consists of small units of Geometry with few basic theorems and results. Further, students' performance in Geometry in Vadamarachchi Educational Zoneis low for the examination conducted by Ministry of Education in Northern Province. In this exam, only forty-three (43) out of one thousand one hundred and thirteen (1113) students got more than 35 marks. Therefore, this study aimsto identify difficulties of learning Geometry for Grade 11students and provide some suggestions for overcoming those issues. Further, in this study we show activity-based methods for teaching Geometry help to increase the student's performance.

Methodology

Research Aim, Objectives, Hypotheses and Research questions

The aims of the study are to identify difficulties of Grade 11 students in learning geometry and provide some suggestions for overcoming in Vadamarachchy Educational Zone. Clearly defined objectives are very important to explore a solution for the research problem. Thus, following four objectives were developed to achieve broad research aim in this study.

- To identify the students' attitude in learning Geometry.
- To identify the relevant background knowledge and concepts for understanding the Geometry.
- To assess students' family background in understanding the Geometry concepts.
- To prescribe the method of teaching and learning Geometry preferred by teachers and students.

The hypothesis formulated in this study is whether the "Teaching methods affect students' Geometry learning".To meet the purpose of the study, the following research questions were formulated.

- How thestudents' attitude affectsin learning geometry?
- How the background knowledge and concepts affect understanding the geometry concepts?
- How students' family background affects in understanding the geometry concepts?
- What methods of teaching and learning of geometry could be prescribed for teachers and students?

In this study, two populations were defined: (1) the students who sat for G.C.E. (O/L) examination in 2016 in Vadamarachchy Educational Zone, there were 1685 such students, (2) the teachers who taught mathematics to grade eleven classes in the schools of Vadamarachchy Educational Zone, there were 69 such teachers.

There are 42 schools in the Vadamarachchy Educational Zone having grade eleven classes. 300 students were randomly selected from these schools as the first sample according to their students' population ratio and 35 teachers were selected as the second sample out of 69 teachers by the technique of convenient sampling.

Table 1: Sample of this Study

Educational Division	No. of schools	No. of students	No. of teachers
Point Pedro	18	152	16
Karaveddy	14	120	14
Maruthankerny	10	28	05
Total	42	300	35

Data Collection Instruments

Data for this study were collected by questionnaires, a diagnostic test, and an experimental teaching activity. Two types of questionnaires were used for the students and the teachers. The diagnostic test and experimental teaching activity were specifically designed for the students. The instruments were personally taken to the schools and administered by with the help of the grade eleven mathematics teachers for the classes involved in the study.

Validity is the most important consideration in developing and evaluation of measuring instruments. Therefore, validity of the questionnaires and diagnostic test were ensured by pilot tests. The questionnaires and diagnostic test were prepared in English and translated into Tamil.

Students' Questionnaire

The questionnaire consisted of two sections. Section A sought personal information about the respondent, while Section B consisted of 17 statements that were to be rated and one open-ended question. The statements in this questionnaire were designed to investigate.

- Students' attitude in learning geometry.
- Students' knowledge related with basic concepts in geometry.
- Students' perception on their mathematics teacher in teaching geometry.
- Family background of Students in learning geometry.

The ratings of the responses are on a five- point Likert scale. The open-ended question gave the opportunity to the students to write their opinions when they identified the problems in solving geometry in the provided spaces.

Teachers' Questionnaire

The questionnaire consisted of two sections. Section A sought personal information about the respondent, while Section B consisted of 20 statements that were to be rated and one open-ended question. The 20 statements in Section B those were to be responded using a five- point Likert scale.

The statements in this questionnaire were designed to investigate.

- Teachers' attitude in teaching geometry.
- Teachers' knowledge in geometry.
- Teachers' perception on their students in learning geometry.
- Teachers' pedagogical aspects in teaching geometry.

Student' Diagnostic Test

The students' diagnostic test had ten questions. In which, six questions were calculating type question, three questions structured type and one was the prove type. Sufficient spaces were allocated on the paper to each question. Students were asked to answer the questions on the paper itself. The diagnostic test was designed to investigate the following abilities of students.

- Students' ability to translate the theorems in geometric and algebraic notation.
- Students' ability to draw the diagram in given geometry problem.
- Students' ability to solve the geometric problem with correct reason.
- Students' ability to remember the theorems, which they learnt in previous classes.

The Scoring for the Students' Diagnostic test

The scoring for the students' diagnostic test was used on a six-point scale based on the rubric designed by Randall Charles as presented by Ottis and Offerman (Ottis, 1988)in Table 3.3 below.

Table 2: The Rubric for Scoring Diagnostic Test

Number of Points	Observed Characteristics in solving problems
0	Incorrect answer or no work shown
1	Correct answer without any work or reason
2	Apply correct relationship without reason and Incorrect answer
3	Apply correct relationship without reason and correct answer
4	Apply correct relationship with reason and incorrect answer
5	Apply correct relationship with reason and correct answer

Experimental Teaching Learning Process

Based on the diagnostic test marks, it was notice examined that J/Vigneswara College has students with average performance for the diagnostic test. Therefore, this school was selected for the experimental research study and 40 students had participated in this study. Based on the diagnostic test marks they were divided in to two comparable groups: experimental group and control group. Mid-point theorem was taughtto the control group and the experimental group using the conventional teaching method and an activity-based teaching method,

respectively. An assessment was done after the delivering the lecture and the assessments marks of the two groups were compared.

Strategy for Data Analysis

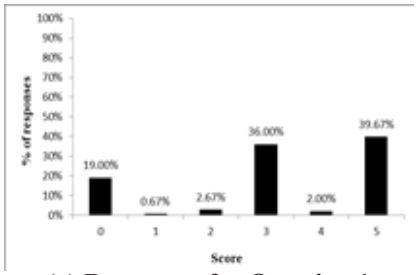
The type of responses that participants provided to the tasks were analyzed about information gathered from the literature study. The statements in both the students' and teachers' questionnaires were categorized into themes and responses were presented on bar charts in which the frequencies for the related items were reflected. Further results of experimental study were analyzed by pair t-test using Minitab software.

Data Analysis and Finding

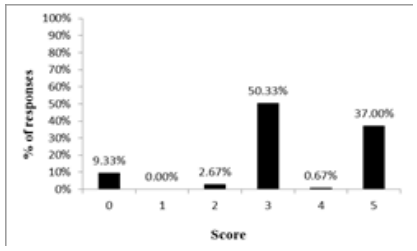
In this section, the data which were gathered by the diagnostic test for students and teachers, students' questionnaires, and results of the experimental research were analyzed in quantitative manner using MS Excel and Minitab.

Students' Responses on Diagnostic Test

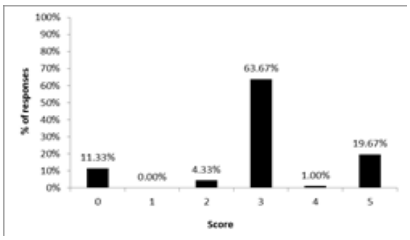
The diagnostic test had included ten questions among them six questions were calculating type, three questions structured type and one prove type question. These questions are related theorem and axioms based on their previous classes.



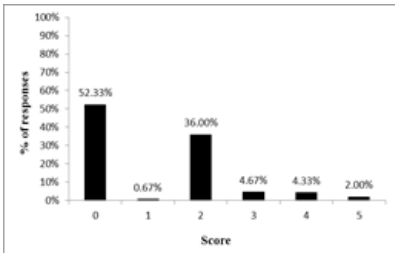
(a) Responses for Question 1



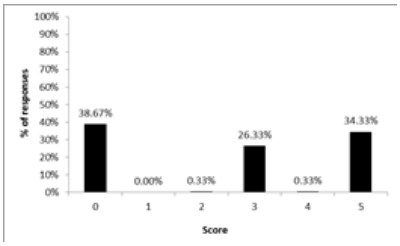
(b) Responses for Question 2



(c) Responses for Question 3



(d) Responses for Question 4



(e) Responses for Question 5

Figure 1: shows the distribution of responses on diagnostic test Question 1- Question 5.

Figure 1: Summary of responses for Question 1 to Question 5

Figure 1 (a) shows the distribution of responses on diagnostic test Question 1- Question 5. Question 1 is based on theorem "The sum of two adjacent angles on a straight line is 1800". Here, 37% of students gave the answers correctly with reasoning and 9.33% of responses are incorrect. But most of the responses (50.33%) were answered this question correctly without giving sufficient reasoning for the answer. This leads the conclusion that the most of the students knew the theorem, but they faced the problems in method of answering. Figure 2 (a) represents the responses of the Question 2, which is based on the theorem "The sum of the angles formed by meeting a few lines at a point is 3600". Here,19.67% of the respondents were given correct answers with

correct reasoning and 11.33% of responses incorrect. However, 63.67% of the respondents answered this question correctly without reasons. Therefore, most of the respondents knew this theorem but they faced problems in answering. Question 3 related with the theorem of when a transversal cut a pair of parallel straight lines forming corresponding angles are equal, alternate angles are equal and sum of pair of allied angles is 1800. According to the Figure 3, 19% of the respondents show incorrect answer to this question and 75.67% of the respondents were given correct answer, among that 36% of respondents gave correct answer without reasons. Question 4 checks the knowledge of the sum of pair of allied angles is 1800 and the properties of parallelogram. Figure 4 shows thedistribution of scores of the respondents for this question. 34.33% of the respondents scored 5 marks and 38.67% of the respondents got zero marks. Even 26.33% of respondents scored 3 marks. That means they answered correctly but did not write correct reasons. Question 5 checks the knowledge in the students related to the Pythagoras theorem of the right-angle triangle. Based on the Figure 5, 52.33% of respondents got zero marks, only 2% of respondents got five marks and 36% of respondents got two marks. This means they had the knowledge related with Pythagoras relationship even did not get correct answer because they troubled in solving binomial equation. Most of the students had insufficient knowledge in Pythagoras theorem and in application.

Analyzing Question 6

This question is a structured type and it consists of four parts. First part of this question checks the knowledge of the students with related to the theorem of when a transversal cut a pair of parallel straight lines forming alternate angles are equal. Second part of this question checks the knowledge of the students that was the properties of the isosceles triangle. Third part of this question check the knowledge of the students with related to the theorem of sum of the adjacent angles on a straight line is 1800 and the last part of this question was checking the knowledge of the theorem of sum of the interior angle of triangle is 1800.

Table 3: Students' Responses on Diagnostic Test Question 6

Question number		0	1	2	3	4	5
6	I	117 (39.00%)	0 (0%)	0 (0%)	20 (6.67%)	0 (0%)	163 (54.33%)
	ii	133 (44.33%)	0 (0%)	0 (0%)	19 (6.33%)	0 (0%)	148 (49.33%)
	iii	91 (30.33%)	38 (12.67%)	1 (0.33%)	8 (2.67%)	0 (0%)	162 (54.00%)
	iv	192 (64.00%)	25 (8.33%)	0 (0%)	1 (0.33%)	0 (0%)	82 (27.33%)

According to the Table 3, 61.67% of the respondents got zero marks in the part question number one and rest of the respondents got full marks. From this most of the students had not clear understood of this theorem. 80.33% of respondents got zero marks in the part question number two and 19.67% of respondents got full marks. So, students had insufficient knowledge of the properties of the isosceles triangle. 83.67% of the students got zero marks in the part question number three and rest of the students got full marks. So, students face the problem that to apply suitable theorem on a particular situation. Finally, 85.33% of the students got zero marks in the last part of this question and only 14.67% of students got full marks. Therefore, most of the students faced troubles in remembering and applying the theorem in suitable situations.

Analyzing Question 7

This question consists of six parts and it is also a structured type. First part of this question checks the knowledge of the students related with the properties of the isosceles triangle. The second part and forth part of this question checks the knowledge

of the student's theorem related to exterior angle of a triangle is equal to sum of the measures of the two non-adjacent interior angles. Third part and fifth part of this question calculates thevalues of the angles by applying above theorem and last part of this question evaluates the application of converse theorem of isosceles triangle.

Table 4: Students' Responses on Diagnostic Test Question 7

Question number		Number of Responses based on score					
		0	1	2	3	4	5
7	I	161 (53.67%)	0 (0%)	0 (0%)	8 (2.67%)	0 (0%)	131 (43.67%)
	ii	110 (36.67%)	0 (0%)	0 (0%)	61 (20.33%)	0 (0%)	129 (43.00%)
	iii	131 (43.67%)	65 (21.67%)	0 (0%)	3 (1.00%)	0 (0%)	101 (33.67%)
	iv	123 (41.00%)	0 (0%)	0 (0%)	60 (20.00%)	0 (0%)	117 (39.00%)
	v	135 (45.00%)	46 (15.33%)	0 (0%)	6 (2.00%)	0 (0%)	113 (37.67%)
	vi	15 (51.00%)	0 (0%)	0 (0%)	17 (5.67%)	0 (0%)	130 (43.33%)

Based on the Table 4, 53.67% of the respondents got zero marks in the part question number one and 43.67% got full marks. So,most of the students were trouble to remember and apply isosceles triangle theorem. In the part question number two, 36.67% of students got zero marks and 43% of students got full marks. Further 20% of the students got 3 marks it means they gave correct answer without reason. 33.67% of respondents got full marks in the part question number three, 43.67% of respondents got zero marks and 21.67% of respondent got one mark. In the part question number four, 39% of the respondents showed correct responses, 41% of respondents showed incorrect responses and 20% of respondents got 3 marks. 45% of respondents got zero marks in the part question number five, 37.67% got full marks and 15.33% of the respondents got one marks. 43.33% of the respondents indicated correct responses and 51% of respondents indicated incorrect responses in last part of this question.

Analyzing Question 8

This question is a structured type, and it consists of seven parts. First and six part of this question check the knowledge of the students related to conditions for the congruent of two triangles. Second and seven part of this question checks the knowledge of the students that was the properties of the congruent triangles. Third and fourth part of this question check the knowledge of the students that postulate related with the straight line and fifth part derives solution from the about parts.

Table 5: Students' Responses on Diagnostic Test Question 8

Question number		Number of Responses based on score					
		0	1	2	3	4	5
8	i	84 (28.00%)	2 (0.67%)	0 (0%)	70 (23.33%)	0 (0%)	144 (48.00%)
	ii	71 (23.67%)	0 (0%)	0 (0%)	67 (22.33%)	0 (0%)	162 (54.00%)

8	iii	93 (31.00%)	0 (0%)	0 (0%)	2 (0.67%)	0 (0%)	205 (68.33%)
	iv	92 (30.67%)	0 (0%)	0 (0%)	1 (0.33%)	0 (0%)	207 (69.00%)
	v	76 (25.33%)	1 (0.33%)	0 (0%)	3 (1.00%)	0 (0%)	220 (73.33%)
	vi	92 (30.67%)	0 (0%)	0 (0%)	76 (25.33%)	0 (0%)	132 (44.00%)
	vii	123 (41%)	2 (0.67%)	0 (0%)	46 (15.33%)	0 (0%)	129 (43.00%)

Based on the Table 5, in the part question number one and six, 71.33% and 69.33% of students answered correctly and 48%, 44% of students got full marks, respectively. Even though, 28% and 30.67% of the respondents got zero marks.76.33% and 58.33% of the students answered correctly in the part questions number two and seven respectively and 54% and 43% of students got full marks. Further 23.67% and 41% of respondents got zero makes of this part questions, respectively. So, students had enough knowledge related with congruent of two triangles. Even though, students could notclearly understand of the properties of congruent of two triangles. The students' correct responses for part three and four of these questions as 68.33%, 69% were respectively and 31%, 30.67% were incorrect, respectively. Therefore, students had enough knowledge of postulate related with the straight line.73.33% of students got full marks in part number five question and 25.33% respondents got zero marks.

Analyzing Question 9

This question is proof type question and it consisted of five parts. First part of this question checks the constructing ability of the geometrical diagram for a given geometrical problem. The second part of this question check the theorem sum of pair of allied angles is 1800 and sum of interior angles of a triangle is 1800. Third and fourth part of this questions apply the ability of the students related with alternate angles are equal when a transverse cuts parallel lines and inverse theorem of isosceles of triangle. The final part of this question checks the application ability of properties of parallelogram and properties of the isosceles triangle.

Table 6: Students' Responses on Diagnostic Test Question 9

Question number		Number of Responses based on score					
9	Part i	185 (61.67%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	115 (38.33%)
	Part ii	241 (80.33%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	59 (19.67%)
	Part iii	251 (83.67%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	49 (16.33%)
	Part iv	256 (85.33%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	44 (14.67%)
	Part v	564 (88.00%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	36 (12.00%)

According to the Table 6, more than 60% of the students got zero marks in this question. So Further 61.67% of the respondents got zero marks in part one question and 38.33% got full marks. Therefore, students' trouble for drawing diagram in a particular geometrical problem and student's language ability also affects poor performance in constructing geometrical diagram. The part questions, number two, three, four and five correct performances are respectively 19.67%, 16.33%,

14.67% and 12%. These are very low performances than other questions. The reason for this is 61.67% of the student did not attend to these questions because they failed in part question number one it is related with drawing a diagram to given problem.

Analyzing Question 10

This question related with circular theorems and it consisted of two parts. First part of this question checks the applicable knowledge of the same segmented angles in a circle. The second part of this question related with the theorem, the opposite angles in a cyclic quadrilateral are supplementary.

Table 7: Students' Responses on Diagnostic Test Question 10

Question number		Number of Responses based on score					
10	Part i	239 (79.67%)	6 (2.00%)	0 (0%)	2 (0.67%)	0 (0%)	53 (17.67%)
	Part ii	255 (85.00%)	0 (0%)	0 (0%)	3 (1.00%)	0 (0%)	42 (14.00%)

Based on the Table 7, even though gave diagram, more than 75% of students did not give the correct answer to this question. So, the students' responses are very poor in circular geometrical questions rather than rectilinear plane figure geometrical questions.

Students' Questionnaire Analysis

Section A: Personal Information

In the study, 50% of the respondents were male and 50% were female students. It is observed all the respondents were 15 and 16 years of age. Figure 2 represents the age distribution of the sample. While 7.3% of the respondents were 15 years of age and 92.7% were 16 years of age.

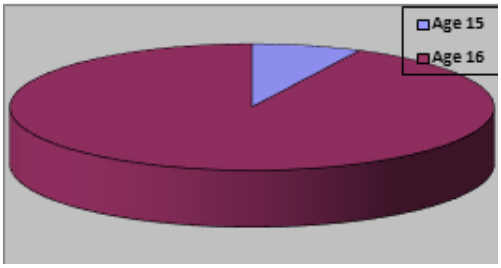


Figure 2: Age Distribution of the Sample

Section B: Students' Data Related to the Study Purpose

The statements in this section were designed to investigate:

- Students' attitude in learning geometry.
- Students' knowledge related with basic concepts in geometry.
- Students' perception on their mathematics teacher in teaching geometry.
- Family background of Students in learning geometry.

The ratings of the responses are on a five-point Likert scale in which:

- Strongly Disagree
- Disagree
- Undecided
- Agree
- Strongly Agree

Students' Attitude in Learning Geometry

Table 8 shows the distribution of students' responses to statements addressing theme one, i.e., Students' attitude in learning geometry. Statements addressed were:

- I like solving geometric problems.
- Geometry is a very difficult section in mathematics.
- I allocate more time for learning geometry.
- I can get distinction pass in G.C.E (O/L) mathematics by without choosing geometry questions.
- Geometry will help to solve real life problems.

Table 8: Distribution of Students' Responses to the Statements 1, 2, 3, 4 & 5

Statements	Number of Responses				
	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
1	82 (27.33%)	62 (20.67%)	37 (12.33%)	77 (25.67%)	42 (14.00%)
2	23 (7.67%)	62 (20.67%)	86 (28.67%)	88 (29.33%)	41 (13.67%)
3	16 (05.33%)	57 (19.00%)	89 (29.67%)	101 (33.67%)	37 (12.33%)
4	91 (30.33%)	75 (25.00%)	73 (24.33%)	32 (10.67%)	29 (09.67%)
5	22 (07.33%)	34 (11.33%)	77 (25.67%)	115 (38.33%)	52 (17.33%)

According to the table 8, 48% of students do not like to solve geometric problem, 39.67% of students like it but 12.33% of students are undecided. The significant percentage (43%) of students think geometry is a very difficult section in mathematics. The 46% respondents indicate that they allocate more times for learning geometry, 55.33% of respondents believe that cannot get distinction pass in G.C.E (O/L) mathematics without choosing geometry questions and 55.66% of respondents agree the geometry will helps to solve their day-to-day problems.

Students' Knowledge Related with Basic Concepts in Geometry

Statements that were related to assess students' prior knowledge related with the basic concepts in geometry are as follows.

- I know very well the geometric terms and symbols.
- A regular polygon has equal sides and equal angles.
- If all side of the rectangle is equal, then it is a square.
- Sum of the interior angles of the triangle is 180o.
- Sum of the exterior angles of the polygon is 360o.
- Circle is a rectilinear plane figure.
- A chord of a circle is a straight line that joins any two points on the circumference.

Table 9: Distribution of Students' Responses to the Statements 6, 7, 8, 9, 10, 11 & 12

Statements	Number of Responses				
	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
6	28 (9.33%)	98 (32.67%)	68 (22.67%)	67 (22.33%)	39 (13.00%)
7	09 (03.00%)	15 (05.00%)	24 (08.00%)	70 (23.33%)	182 (60.67%)
8	37 (12.33%)	22 (07.33%)	40 (13.33%)	40 (13.33%)	161 (53.67%)
9	03 (01.00%)	02 (00.67%)	02 (00.67%)	22 (07.33%)	271 (90.33%)
10	09 (03.00%)	09 (03.00%)	06 (02.00%)	33 (11.00%)	243 (81.00%)
11	164 (54.67%)	40 (13.33%)	34 (11.33%)	37 (12.33%)	25 (08.33%)
12	09 (03.00%)	08 (02.67%)	11 (03.67%)	55 (18.33%)	217 (72.33%)

According to Table 9, 35.33% of respondents agree that they know the geometric terms and symbols as very well but 42% of respondents disagree that they know the geometric terms symbols as very well. 84% of respondents agree that a regular polygon has equal sides and equal angles. 67% of respondents agree that if all side of the rectangle is equal, then it is a square and 19.66% of respondents disagree of this statement. But if all side of the rectangle is equal then the rectangle will be square or rhombus. This result indicates that the students have some confusion regarding the properties of square and rhombus. The 97.66% of respondents agree that sum of interior angle of a triangle is 1800 and 92% of respondents agree that sum of the exterior angle of a polygon is 3600. The 68% of respondents disagree that circle is a rectilinear plane figure and 20.66% of respondents agree with the statement. But circle is not a rectilinear plane figure. 90.66% of respondents agree that chord is a straight line that joins any two points on the circumference of a circle.

Students' Perception on their Math Teacher in Teaching Geometry

The third theme of the investigation is students' perception on their mathematics teacher in teaching geometry. The following statements addressed this:

- Mathematics teacher allows me to use alternative methods in solving geometric problems.
- My mathematics teacher teaches geometry well.
- Teacher gives the chance to solve geometry problems by discussing with my classmates.

Table 10: Distribution of Students' Responses to the Statements 13, 14 & 15

Statements	Number of Responses				
	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
13	08 (02.67%)	22 (07.33%)	60 (20.00%)	108 (36.00%)	102 (34.00%)
14	07 (02.33%)	04 (01.33%	12 (04.00%)	74 (24.67%)	203 (67.67%)
15	03 (01.00%)	07 (02.33%)	18 (06.00%)	109 (36.33%)	163 (54.33%)

According to Table 10, the 70% of respondents agree that their teacher allows using alternative method to solve geometric problem and 10% of respondents disagree in this statement. 92.34% of agree that their teacher teach geometry well and 90.66% of respondents agree that their teacher gives the chance to solve geometry problems by discussing with my classmates.

Family Background of Students in Learning Geometry

The statements in this category were designed to investigate students' family background in learning geometry. These statements were:

- My family members help me to clear doubts in geometry.
- My family provides facilities to have private geometric class.

Table 11: Distribution of Students' Responses to the Statements 16 & 17

Statements	Number of Responses				
	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
16	81 (27.00%)	68 (22.67%)	49 (16.33%)	56 (18.67%)	46 (15.33%)
17	72 (24.00%)	81 (27.00%)	41 (13.67%)	41 (13.67%)	65 (21.67%)

According to Table 11, the 34% respondents are agreed that their family members help them to clear doubts in geometry and 49.67% of respondents disagree this statement. But the 16.33% of respondents were undecided this statement. 35.34% of respondents were agreed that their family provides facilities to them for arrange private tuition classes and 51% of respondents were disagreed this statement.

Students' Responses to the Open-Ended Question

The last part of the students' questionnaire was an open-ended question that provided the respondents opportunity and space to write what they find problematic when solving geometric problems. Here a lot of ideas/opinions were brought up.

Most of the respondents indicated that they experience grate difficulties in draw a diagram for given geometrical problem, how to correlate given data and problem and find which theorems to apply for solving these given geometrical problems. They say sometimes they do not understand what the question really asks them to do. The language is too difficult to understand the problem. One respondent indicates "I faced problem to identify the data for given geometrical problem and how to draw the diagram for this problem". This is also confirmed in students' diagnostic test.

Another problem area mention by most of the respondents is the remembering the theorems that learned in the previous classes. One respondent indicates that "I face difficulties to remember the theorems which are learned in previous classes". This problem already confirmed through the students' diagnostic test.

Most of the student faced difficulties in solving geometric problem, which needs the application of more than one theorem. One of the respondents mentioned that solving geometric question by using only one theorem is not a big issue. This also revealed from the students' diagnostic test.

Teachers' Questionnaires Analysis

The questionnaires consist of two sections, Section A and Section B. Section A is focused on personal information about the respondents. Section B, 20 statements and one open-ended question designed to seek information related to the teaching and learning of solving geometrical problems. The questionnaires were distributed to 35 teachers and were all collected back.

Section A: Personal Information

Respondents' Gender

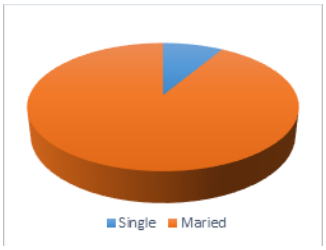
Table 12: Gender of Teachers

Gender	Number	%
Male	16	45.71
Female	19	54.29

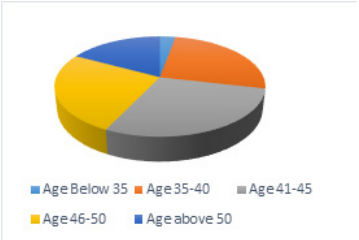
In this study 45.71% of participants are male and 54.29% of participants are female teachers.

Status of Respondents

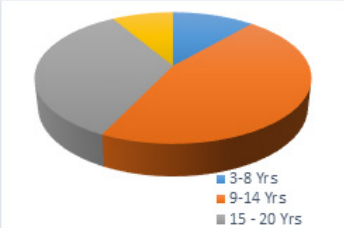
Figure 3 shows the distribution of the sample according to the age, marital service, teaching service, and educational qualification. 8.57% of the respondents were single and 91.43% were married. The sample contains 25.71% of the respondents within 35 – 40 years. 2.86% below 35 years of age and 17.14% were above 50 years of age. 71.43% of the respondents were above 40years of age. Most of the respondents have teaching experience more than 9 years. Only 11.43% of the respondents have the teaching experience below 8 years. Figure 4(d) indicates that most of the respondents are well qualified with a degree or postgraduate degree.



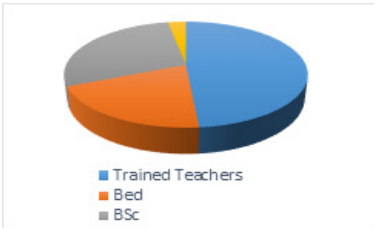
(a) Marital Status



(b) Age



(c) Teaching Service



(d) Educational Qualification

Figure 3: Distribution of the Sample

Section B: Teachers' Data Related to the Report

This section was made up of 20 statements that were responded to use a five- point Likert scale in which:

- Strongly Disagree
- Disagree
- Undecided
- Agree
- Strongly Agree

The statements in this section were designed to investigate.:

- Teachers' attitude in teaching geometry.
- Teachers' knowledge in geometry.
- Teachers' perception on their students in learning geometry.
- Teachers' pedagogical aspects in teaching geometry.

The last item on the questionnaire is an open-ended one. Here participants were provided with opportunity and space to say what seems problematic to students in solving geometric problem and how they think these problems may be addressed.

Teachers' Attitude in Teaching Geometry

The following Table 13 shows that the distribution of responses this aspect as reflected by statements 1, 2, 3 and 4. The statements were:

- The students, who have not selected geometric questions, can obtain distinction pass for mathematics in their G.C.E (O/L) Examination.
- I am interested in teaching geometry.
- The geometric section helps the students to develop their logical thinking.
- The geometric section is more difficult than the other mathematics sections so students cannot understand clearly.

Table 13: Distribution of Teachers' Responses to the Statements 1, 2, 3 & 4

Statements	Number of Responses				
	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
1	11 (31.43%)	11 (31.43%)	04 (11.43%)	06 (17.14%)	03 (08.57%)
2	0 (00.00%)	0 (00.00%)	0 (00.00%)	08 (22.86%)	27 (77.14%)
3	0 (00.00%)	0 (00.00%)	0 (00.00%)	08 (22.86%)	27 (77.14%)
4	04 (11.43%)	12 (34.29%)	05 (14.29%)	12 (34.29%)	02 (05.71%)

According to the Table 13 indicate that 100% of the respondents agree that they teach geometry interesting, and they believe that the geometry section help to students to develop their logical thinking. 62.86% of the respondents disagree that the students, who have not selected geometric questions, can obtain distinction pass for mathematics in their G.C.E (O/L) Examination. 11.43% of the respondents were undecided and 25.71% were agreed in this statement. 40% of the respondents agree that the geometric section is more difficult than the other mathematics sections so students cannot understand clearly. But 45.72% of the respondents were disagreed this statement and 14.29% were undecided.

Teachers' Knowledge in Geometry

Statements that were related to assess teachers' knowledge in geometry are as follows:

- I have sufficient knowledge to teach geometry concepts.
- I know geometry terms and symbols very well.

Table 14: Distribution of Teachers' Responses to the Statements 7 & 8

Statements	Number of Responses				
	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
7	0 (00.00%)	0 (00.00%)	0 (00.00%)	14 (40.00%)	21 (60.00%)
8	0 (00.00%)	0 (00.00%)	0 (00.00%)	11 (31.43%)	24 (68.57%)

The Table 14 indicates that 100% of respondents were agreed that they have sufficient knowledge to teach geometry concepts and they know geometry terms and symbols very well.

Teachers' Perception on their Students in Learning Geometry

The statements in this category were designed to investigate teachers' perception on their students in learning geometry. These statements were:

- The students can easily solve geometric problem.
- Students show less interest in learning geometry.
- Students can understand the geometric section logically.
- It takes much time even to intelligent students to understand the concept of geometry.
- Students' response is very low in geometrical drawing.
- Students use the geometric terms and symbols properly.
- Students use geometric knowledge in their day-to-day life.

Table 15: Distribution of Teachers' Responses to the Statements 9, 10, 11, 12, 13, 14 & 15

Statements	Number of Responses				
	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
9	1 (02.86%)	19 (54.29%)	8 (22.86%)	6 (17.14%)	1 (02.86%)
10	0 (00.00%)	4 (11.43%)	4 (11.43%)	20 (57.14%)	7 (20.00%)
11	3 (08.57%)	18 (51.43%)	6 (17.14%)	8 (22.86%)	0 (00.00%)
12	1 (02.86%)	12 (34.29%)	6 (17.14%)	16 (45.71%)	0 (00.00%)
13	1 (02.86%)	4 (11.43%)	7 (20.00%)	14 (40.00%)	9 (25.71%)
14	4 (11.43%)	18 (51.43%)	8 (22.86%)	5 (14.29%)	0 (00.00%)
15	1 (02.86%)	12 (32.29%)	10 (28.57%)	11 (31.43%)	1 (02.86%)

According to the Table 15, 57.15% of the respondents were disagreed the statement "students can easily solve geometric problem." 20% of respondents agree this statement but 22.86% were not able to decide about the statement. 77.14% respondents agree that the students less interest in learning geometry, 11.43% of respondent'sstatus is undecided about the statement and 11.43% respondents disagreed. 60% respondents were reflected as disagree that students can understand the geometry section logically and 22.86% respondents agreed. 45.71% of the respondents agree that the intelligent students take much time to understand the concept of geometry and 37.15% respondents disagreed with this. 65.71% respondents were agreed that students geometrical drawing is low, and 20% respondent's status is undecided. 62.86% respondents did not agree with the statement that students use the geometric terms and symbols properly and 34.29% respondents were agreed that

students use geometric knowledge in their day-to-day life.

Teachers' Pedagogical Aspects in Teaching Geometry

Quite several statements focused on this aspect. These are statements 5, 6, 16, 17, 18, 19 and 20. The purpose of these statements is to seek information on what teachers regard as good teaching and practices that they engage in helping their learners develop understanding of taught concepts. The following statements addressed this:

- Enough periods allocated for teaching geometry in curriculum.
- More attention is focused on the seminars and workshops regarding geometry teaching and learning.
- I get trouble when establishing geometric concepts among students.
- I teach geometry with pre-plane and successfully.
- I stress the geometric terms and symbols in proper place while teaching.
- I mostly used group activity method for teaching geometry.
- When teaching geometric concepts, it is better to give real world example.

Table 16: Distribution of Teachers' Responses to the Statements 16, 17, 18, 19, 20, 21 & 22

Statements	Number of Responses				
	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
16	4 (11.43%)	12 (34.29%)	5 (14.29%)	9 (25.71%)	5 (14.29%)
17	5 (14.29%)	12 (34.29%)	9 (25.71%)	8 (22.86%)	1 (02.86%)
18	0 (00.00%)	1 (02.86%)	6 (17.14%)	24 (68.57%)	4 (11.43%)
19	0 (00.00%)	0 (00.00%)	3 (08.57%)	29 (82.86%)	3 (08.57%)
20	0 (00.00%)	0 (00.00%)	0 (00.00%)	21 (60.00%)	14 (40.00%)
21	7 (20.00%)	13 (37.14%)	3 (08.57%)	8 (22.86%)	4 (11.43%)
22	1 (02.86%)	2 (05.71%)	0 (00.00%)	19 (54.29%)	13 (37.14%)

From the above responses in Table 16, it can be noticed that 40% of respondents believe that enough periods allocated for teaching geometry in syllabus. Further 48.58% of respondents mentioned that less preference gave to geometry teaching and learning in the seminars and workshop. 80% of respondents' response that they get trouble when establishing geometric concepts among students. 91.43% respondents indicate that they teach geometry with pre-plane successfully.100% of respondents' response that they stress the geometric terms and symbols in proper place while teaching and 57.14% respondents disagree that they used group activity method when teaching geometry section in the classroom. 91.43% of respondents believe that the usefulness of giving real world examples when teaching Geometry concepts.

Teachers' Responses to the Open-Ended Question

In this part of the questionnaire, participants were required to indicate whether their students face difficulties to solve geometric problem and further they were asked to how to improve students' geometric problem-solving abilities.

The majority (85.72%) of the respondents indicated that students faced difficulties in drawing accurate diagram by reading the data of given geometrical problem. Only 14.28% of the views indicated that their students were able to solve such problems.

From the respondents' perspective, students' main problem concerns proof type geometric question rather than calculating type geometric question and students face great difficulty in solving

the geometrical problem by applying more than one theorem in a situation. Further, most of the students do not have clear knowledge about prior geometrical concepts that they learned in the previous classes.

Final Summary of Diagnostic Test and Questionnaires

Table 17: Summary of Diagnostic Test and questionnaires

Student Diagnostic Test	Students' Questionnaires	Teachers' Questionnaires
• Most of the students (80%) knew basic theorem but they face in method of answering. • More than 50% of student's insufficient knowledge in Pythagoras theorem • Student had insufficient knowledge about properties of parallelogram and isosceles triangles. • Students have great difficulties for solving geometric problem by using more than one theorem applying at an instance. • Students faced difficulties to remember the theorems and applying in suitable situations. • Students faced difficulties to understand the properties of congruent tringles. • Students faced difficulties in prove type geometrical question rather than the calculating type questions. • Students faced difficulties in constructing geometrical diagrams for a given problem. • Students' language ability affect learning geometry	• Students have negative attitudes in learning geometry rather than other sections. • Students faced difficulties in understanding the geometry concepts and theorems. • Students had positive attitudes with their mathematics teacher. • Most of the students did not get any help from their family members.	• Teachers had positive attitude in teaching geometry. • They said most of the students did not interest in learning geometry. • Most of the students faced difficulties in drawing geometrical diagrams. • Students faced difficulties to use geometrical symbols properly. • Students faced great difficulties in solving prove type geometry questions. • They said allocated periods to the geometry section not enough to do more practices in the classroom. • Priority of the geometry section in the seminar did not give less attention. • Most of teaches teach geometry by using conventional teaching method.

Results of Experimental Teaching Methods

Pre – Test Results Analysis

The pretest was administrated in both experimental and control groups. The score of pretests were analyzed in quantitatively and followed by an interpretation and discussion on results. The significance was tested using t-test for two independent samples.

The table 18 presents the pre-test results of the two samples which were given to assess the comparability of the two samples before the experiment.

Table 18: Descriptive Statistics for Pre-Test

Group	N	Mean	Std. Deviation
Control	20	49.3	16.3
Experimental	20	52.0	13.6

Difference = μ(Control group) - μ (Experimental group)

Estimate for difference: -2.75

95% CI for difference: (-12.39, 6.89)

t-value = -0.58p-value = 0.566 DF = 36

The difference between the two groups were analyzed by the t-test at α =0.05 level of significance. The p-value is greater than 0.05, the evidence strongly suggests that there is no significance difference between the mean of the two groups population. Therefore, the two groups the control and experimental groups were of the same levels in their achievement of content at the beginning of the experiment.

Post Test Results Analysis

The same posttest was administrated in both experimental and control groups in the end of the experimental teaching. The scores of posttests were analyzed in quantitatively using t-test.

Table 19: Descriptive Statistics for Post-Test

Group	N	Mean	Std. Deviation
Control	20	52.0	15.0
Experimental	20	68.0	16.7

Difference = μ (Control group) - μ (Experimental group)

Estimate for difference: -16.00

95% CI for difference: (-26.15, -5.86)

T-Value = -3.19 P-Value = 0.033 DF = 37

Formulating Hypothesis

H_0:There is no significant difference in the achievement of two groups.

H_1:There is a significant difference in the achievement of two groups.

The differences between the two groups were analyzed by t-test at α =0.05 level of significance of the p-value is less than 0.05, therefore, the null hypothesis is rejected. So, there is enough evidence to say that there is significance difference between the two group populations. That means the experimental group performance is significantly better than control group. Therefore, the activity-based teaching performed better than the conventional based teaching.

Discussion and Conclusion

Geometry section in the mathematics curriculum plays an important role in G.C.E. (O/L) Mathematics Examination. The G.C.E. (O/L) mathematics syllabus has been developed based on six themes, such as Number, Geometry, Algebra, Measurements, Set and Probability and Statistics (NETS, 2015). The weight percentage in G.C.E. (O/L) mathematics examination for every theme is as follows: (1) Number (22%), (2) Geometry (23%), (3) Algebra (20%), (4) Measurements (15%), (5) Set and Probability (10%) and (6) Statistics (10%). It can be clearly observed that the highest weight is allocated for geometry section. However, we found that the students show low performance in G.C.E. (O/L) mathematics examination as well as in term examination in Geometry section. Therefore, this study was aimed to identify the difficulties of grade 11 students in learning Geometry and provide some suggestions for overcoming the difficulties. Specifically, this study is a quantitative survey and an experimental research. The random samples for this study chosen from an eleventh-grade student-population and eleventh-grade grade math teachers were 300 and 35, respectively in Vadamarachchy educational zone. Questionnaires and Diagnostic test were used to collect data from students, while only the Questionnaires were used to collect data from teachers. Here forty students were selected for the experimental research and they were divided into two equally talented groups based on diagnostic test. Then two different types of teaching methods (activity based and the conventional teaching methods) were applied with groups 1 and 2 respectively. The collected data were analyzed using MS Excel 2010 and Minitab16. Findings from the study exposed that students had greater difficulties in drawing diagram for given geometrical problem and they faced difficulties in applying more than one theorem to solve a given geometrical problem. Students' low interest in geometry and their family background affect their geometry learning. Further the findings indicate that the activity-based teaching method is more effective than the conventional method of geometry teaching.

Most of the Students do not Interest for Learning Geometry

Students and teachers think geometry is a difficult section in mathematics. Most of the teachers teach geometry in traditional teaching. According to the

teachers' opinions, the time allocation for teaching geometry is not enough in curriculum so teachers do not give enough practices and some time they omit geometry section.

Students have Insufficient Prior Knowledge in Geometry

Students take insufficient practices in Geometry sample questions. Nowadays teachers do not give more attention to teach geometry because they need to increase the pass percentage of mathematics as without answering to the Geometry part in the Mathematics paper, students are able to achieve a pass in G.C.E. (O/L) examination.

Students' Family Background Affects in the Geometry learning.

Most of the students cannot get help from their family members to learn geometry in their home because background knowledge of the geometry in their parent is poor. Economic status of parents make barrier to student to gain more knowledge in geometry.

Method of Teaching Affects Students' Geometry Learning

Most of the teachers used to teach geometry in traditional method. But the activity-based teaching method is better than traditional method. In the traditional method students are the passive learners, it is a one-way communication method and mostly teacher centered. In activity-based teaching method students are active learners, mostly student centered, and it is a multi-way communication method.

Limitation of this Study

This research was done only in Vadamarachchy educational zone. The experimental research was done only in one school and for only one unit. The students' family background, their family income, and the support from the family members to learn geometry were only considered.

Suggestion for Overcoming Difficulties in Learning geometry

As suggestions, we propose teachers should provideреal-world examples when teaching the Geometry concepts. Teachers must attend the seminars update their knowledge with new teaching techniques, such as computer software to teach Geometry effectively. Also, new concepts in Geometry can be introduced to students by recalling prior knowledge through the activities. According to the teaching experiment results, activity-based teaching methods are recommended for teaching Geometry.

By implementing activity-based teaching methods, students get positive attitude in geometry and get good achievement in mathematics. Therefore, not only increases the number of students in learning G.C.E (A/L) mathematical stream but also the ability of solving day-to-day life problems with help of geometrical knowledge.

This research was done with the factors such as student's attitude, prior knowledge, family background and teaching methods. Other factors may also affect learning geometry. Further research could be carried out to investigate the other important factors which can influence learning geometry. We intend to devote ourselves in this direction of future work.

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