# Chapter I

# INTRODUCTION

## Background of the Study

Mathematics is dynamic, living and cultural product. It is a study of number and their operation, interrelations, combinations, and of space configurations and their structure, measurement, transformation and generalization. Mathematics is the study of numbers, shapes, and space using reason and usually a special system of symbols and rules for organizing them (Cambridge Advanced Learner's Dictionary, 2017).

Mathematic is a form of reasoning. Thinking mathematically consist of thinking in a logical manner, formulating and testing conjectures, making sense of things and forming and justifying judgements, inferences and conclusions. We demonstrate mathematical behaviours when we recognize and describe patterns, construct physical and conceptual models of phenomena, create symbol system to help us to represent, manipulate and reflect on ideas and invent procedures to solve problems (Battista, 1999).

Geometry is one of the most useful and important branch of mathematics. The word Geometry is derived from the Greek word 'Geo' and 'Metry', which means "earth measure" or measurement of the earth. Without geometry, the development of other area of mathematics relating to the study of space and the relationship between points, lines, curves and surfaces would have been incomplete. It is one of the mother structures of mathematics which is found by Euclid in 300 BC. It explains about quantity, change, structure and spatial relationship. According to historical evidence, the origin of geometry is Babylonian, Egyptians and Greek. Greek geometrician Plato advocated that “Let no man ignorant of geometry enter” for the development of the geometry education. Geometry was developed by extensive involvement in trade, practical considerations and measuring earthly things. Geometry is used in our everyday life because we see it everywhere.

Geometry is the growing body of knowledge with ever widening application and inherent beauty in its systematic structure and organization. It is not known the full extent to which geometric and numerical relationships were understood and used in very ancient times. But evidence indicates that until about 600 BC, all mathematical knowledge consisted of various “rule of thumb” formulas or procedures that were obtained from experience and that gave useful approximations, at least in special cases. Later it was replaced by the rule of reasoning. However, it is not certain who first had the idea of trying to prove a mathematical rule by reasoning rather than by testing it in different cases (Pandit, 2010, p.1).

Due to the lack of suitable approaches of teaching methods, geometry seems difficult part in mathematics. Even the excessive use of expository method of geometry teaching, students are found unable to understand the properties of geometrical figures. In geometry teaching, most of the students copy what the teachers write on the board, which is worst method of teaching and is not an efficient method of teaching and learning of geometry. Even though student spent most of the excessive time in study, they felt geometry is a hard subject to study. With the different learning problems of geometry, different cognitive theories have been developed. The van-Hiele’s level of thinking is new and the theory of instruction could be an alternative pedagogy for teaching geometry.

In the late 1950s in the Netherland, two mathematics teachers, Pierre van Heile and Dina van Hiele- Geldof, husband and wife, put forth theory of development in geometry based on theory own teaching and research. They observed that in learning geometry, student progress through a sequence of five reasoning levels, from wholistic thinking to analytic thinking to rigorous abstract mathematical deduction (Pandit, 2010, p.453).

Pierre van Hiele and Dina van Hiele – Geldof were inspired by Jean Piaget's idea of level of understanding of mathematics, notably linked to the age. They tasted that idea, and empirically developed and derived the van Hiele levels of insight, more independent of age. Pierre van Hiele has been teaching mathematics on various topics for two decades and had observed the levels in various topics, and indeed in various disciplines, like chemistry and didactics itself. His thesis merely took geometry as an example, or, rather as the example par excellence, as geometry is a foundation stone for the mathematics as the art and science of demonstration. His thesis provided in mathematical fashion both a definition of the levels in human understanding and an existence proof (Colignatus, 2015).

The van Hiele model, developed by two mathematics educators, has been used since the early 1980s to explain why students have difficulty with high school geometry in general, specially, higher order cognitive processes. The van Hiele level theory (van Hiele, 1957) which was developed in 1957, theorized that there are five ordered levels of understanding that each students go through the gain complete understanding, identified by van Hiele-Geldof as scientific insight into geometry. As van Hiele was a teacher of mathematics he used examples from geometry to illustrate his levels though he did not restrict his theory to mathematics.

Most of the students seem to be weak in geometry. The reasons behind this bitter fact are; untrained teacher, lack of teaching material and methodology, uninterested curriculum for students etc. van Hiele developed five levels of thoughts on the issues why students feel difficulties in geometry. Each level tests achievement of students in geometry. This method is necessary for determining; how is the geometric achievement of students in lower level and how their weaknesses and increment is in level wise geometric knowledge in arriving from lower level geometric achievement to higher level geometric achievement. Actually, a math teacher is required to know difficulties faced by students in geometric study. As a result, it becomes helpful for students in learning geometry. In Nepal, most of the schools, teacher teaches based on the course related topics rather than learning difficulties and problems of students. As a result, achievement of students in mathematics declines. For which, the teacher should teaches level wise. This research study has been carried out to find out the achievements in arriving from lower level achievement to higher level and the relation of achievement of geometry in achievement of mathematics.

**Statement of the Problem**

Geometry teaching has always been challenging for teacher, but due to the negative attitude and neglecting performance towards geometry teaching of teachers, owing to students' poor performance, teacher are often seems confuse towards to use proper method for geometry learning and they go through the traditional way, which gave confused to identify the possible causes of hindrances in students' learning of geometry, which gave the poor results in geometry of students.

In order to ascertain the effectiveness of the van Hiele's approach towards the geometry teaching the study intended answer the following questions:

1. What van Hiele levels of geometric thinking do grade 10 students attain by the end of the academic year?
2. Is there a relationship between van Hiele level of geometric thought and mathematics achievement of the students?

**Significance of the Study**

This study would have the following significance:

1. Practiced students' van Hiele levels of reasoning may assist teacher to organize teaching learning program properly.
2. It makes teacher to be able to assign students various van Hiele levels and prepare suitable directions more appropriately. Teacher can amend the way they teach to cope the challenges emerged from a diverse group of learners.
3. Curriculum developers and text book authors would be benefited to align their material more closely with the VH model.
4. Teacher training institution can use the ways of finding VH models and predictor of mathematics achievements.

**Objectives of the Study**

The objectives of the study were as follows:

1. To determine the van Hiele levels of geometric thinking of grade 10 students.
2. To explore the relationship between mathematics achievement and van Hiele level of geometric thought.

3. To explore the teachers' perspectives on van Hiele level of geometric thinking.

**Hypothesis of the Study**

This study would attempt to seek the result of following hypothesis:

a. **Research Hypothesis**

A student's van Hiele level of thought is positively correlated with his/her mathematics achievements.

**b. Statistical Hypothesis**

$H_o: \rho = 0$ (null hypothesis)

$H_1: \rho \neq 0$ (alternative hypothesis)

Where $\rho$ is the coefficient of correlation between students' van Hiele level of geometric thought and their achievement in mathematics.

**Delimitation of the Study**

This study has the following delimitations:

1. Only schools of Tanahun district were included. It shall not be appropriate to generalize the result of survey in other districts.
2. This study is concerned only with the students of grade X. Also the shortcoming of this study is selected number of schools and the students involved in this study.
3. Students' score in achievement test were obtained from corresponding schools' record of grade x.
4. Students were assigned different van Hiele level only by using paper-pencil test namely VHGT.

5. The limitation of this survey is the multi-dimensional approach has not been applied in data collection.
6. The researcher depended on international research findings on the van Hiele theory due to the lack of national or local level studies.

**Definition of the Related Terms**

*Van Hiele levels:* According to van Hiele, children learn geometry through five levels named as visual, analysis, informal deduction, deduction and rigor. According to van Hiele, a learner passes through these levels when assisted by appropriate instructional experience and that a learner cannot achieve one level of thinking without passing through the previous levels.

*Achievement:* In this study the word achievement is defined as the magnitude of score obtained by the students in the school examination in mathematics that has been administered by school.

*VHGT:* VHGT is the Van Hiele Geometric Test, which was used by van Hiele. It is the analysis of Cognitive Development and Achievement in Secondary School Geometry (CDASSG) test. VHGT consist of different multiple choice questions in the order with 0-4, in order to find the level of students.

*Level of thinking:* According to the theory, there are five levels of thinking or understanding in geometry, students attained 0-4 levels as recognition, analysis, abstraction, deduction and rigor.

# Chapter II

# REVIEW OF RELATED LITERATURE

This chapter present the review of the literature in the field of geometry and van Hiele's method of geometric instruction. Specifically the review of literature has been described into three parts; empirical, theoretical and conceptual framework.

## Empirical literature

The review of literature consists of analysis and systematic identification of documents related to the study under taken, of the existing literature related to the research study. The researcher tried to find out the literature on the topic that related to the problem faced by mathematic students in learning geometry. However there is lack of literature directly related to current study of libraries of Nepal. Some of the literatures reviewed by researchers which are related to the present study are discussed here:

Usiskin (1982), studied on “van Hiele Level and Achievement in Secondary School Geometry”. He developed a multiple choice test to measure a student's van Hiele level of reasoning. He wanted to find out if these test could at all predict student achievement in geometry. He tested 2699 $10^{th}$ graders and looked for a correlation between their van Hiele level and their geometry grades. The result showed that there was moderately strong relationship (r=0.64). He consistently found that most tenth graders were not ready for high school geometry. They were generally at level 0 or 1 and had little experience of recall or geometry before their high school course.

Atebe (2008), undertook his Ph.D dissertation entitled “Students’ van Hiele level of Geometric thought and Conception in Plane Geometry: A Collective case Study of Nigeria and South Africa “with the objective to explore and explicate the van Hiele level of geometric thinking of selected group of grade 10, 11, 12 learners in Nigeria and South African school, and to provide a rich and in- depth description of geometric instructional practices that possibly contributed to the level of geometric conceptualization exhibited by this cohort of high student learner. For this collective study Nigeria and South Africa, selected by purposively and stratified sampling. He used Usiskin’s test, interview, classroom video and hands on activities to collect the data. His study revealed that:

1. Most of the learners were not yet ready for the formal deduction study of school geometry, only two and three percent of them were respectively at van Hiele level 3 and 4.
2. His research related to gender difference in performance generally favoured the male learners.
3. Furthermore, his study showed that learners’ van Hiele level strongly correlate with their performance to geometry content test and mathematics generally. For $n \leq 2$ learner at van Hiele level ‘n’ obtained higher means on nearly all the test administered in his study than their peers at level ‘n-1’.

Meteya (2008), conducted a study on “using van Hiele theory to Analyze geometrical conceptualizationin grade 12 students: A Namibian Perspective”. The result of his study indicated that many of the students who participated in the research had weak conceptual understanding of geometric concepts. The findings of his study also highlighted the issues of how the Namibian grade 12 geometry syllabuses should be aligned with the van Hiele levels of geometric thinking as well as the use of the appropriate and correct language in geometrical thinking and problem solving.

Pusey (2003), carried out a thesis entitled “The van Hiele Model of Reasoning in Geometry: A Literature Review”. The objectives of his study were to describe the van Hiele Theory in detail, present research related to van Hiele model, synthesize the result of such studies, compare the van Hiele model to other theoretical model and discuss classroom implication. His research highlighted four different areas with respect to van Hiele model.

1. Appropriate way to assess to students’ level of geometric reasoning and result of those assessments.
2. Assessment of pre-service and in-service teachers’ level of reasoning.
3. Instructional intervention used with students based on the van Hiele model.
4. Intervention with both pre-service and in-service teacher to promote awareness of the theory and improved knowledge of geometric contents.

He found in his study that there were three broad categories of research done in van Hiele model. The first Core Avenue of research has focused on testing the van Hiele theory itself and assumption. A second avenue of research has to find appropriate ways to assess the level and discuss implication of these assessments. A third avenue of research with van Hiele theory has looked at the effect of intervention with students and teacher based on the model, with students the research has sought to determine if instruction based on van Hiele’s recommendation is effective in fostering improved reasoning.

Lamsal (2005), conducted a study on "A study on the effectiveness of van Hiele approach in teaching geometry at lower secondary level" aimed at exploring the effectiveness of the van Hieles' approach in teaching geometry. The population of his study was eight grade students enrolled in the public school in Syanja district. He experimented on the forty nine pupils of the sample with the help of teaching module as a research tool. In his study he found that mean achievement score of the student taught by van Hiele approach was higher than that of taught by conventional approach.

Knight (2006), did his thesis entitled " An investigation into the change in the van Hiele levels of Understanding geometry of pre-service elementary and secondary mathematics teaching", to show statistically significant findings that the van Hiele level of pre-service elementary and secondary mathematics teachers are not at the level expected of their potential students prior to completion of geometry course required by their program of study and to determine, pre-service elementary and secondary mathematics teacher is statistically significantly equal to or higher than expected of their potential students after completion of geometry course. The population of this study was the students enrolled in MAT 107 and MAT 475 at the University of Maine during the fall semester of 2005. He used Usiskin's 1982 CDASSG project to test the pre and post test. His study revealed that:

1. van Hiele level of understanding geometry for pre-service elementary and secondary mathematics teachers, both before and after completing their program of study is statistically significantly lower than the levels expected of their target audience.

2. Students may attain understanding at the next higher van Hiele level but that new level just isn't the level at or above the level of their expected audience.
3. Additional instruction is needed for the pre-service elementary teachers, who are not already at level 2 and secondary mathematics teacher who are not already at level 3.
4. In addition, instruction should provide these future teachers with the opportunity, through additional content courses or seminar, to attain understanding at these levels and therefore help them to be successful in the current courses that are offered.

Oli (2011), did his thesis entitled "Students' van Hiele level of geometric thought and their relationship to their achievement in mathematics". He designed survey study to explore the relationship between the van Hiele levels and achievement of the students in geometry. The population of his study were grade 10 students enrolled in 6 secondary schools in Salyan district by using stratified random sampling method. 230 studentsand six teachers were selected from the selected schools. In order to assess the students' van Hiele level, adopted version of VHGT developed by the staff of the CDASSG project was employed as a main research tool. This study revealed that students of grade 10 were not adequately prepared to understand the concept of geometry most of the students of this study were below the VH level 1. The conclusion of reached was that there is a strong relationship (0.85) between performance in mathematic (VHGT and SEM) and van Hiele levels for the majority of the students. Thus van Hiele theory is one of the frameworks in exploring students' geometric reasoning.

**Theoretical Framework of the Study**

The work of two Dutch educators, Dina van Hiele –Geldof and Pierre van Hiele, has been influencing the teaching of geometry. They were concerned about the difficulties their students were having with geometry, so they conducted research aimed at understanding children's levels of geometric thinking to determine the kinds of instruction that can be help children. Van Hiele describes how children think about geometric concept in different level. In mathematics education, this model is a theory that how the children learn the geometry. The theory originated in theses at the University of Utrecht in 1957. Their theory explains why the many students encounter difficulties in their geometry course, especially with the formal proofs. The van Hiele believes that written proofs requires thinking at comparatively high level, and that many students need more experiences in thinking at lower levels before learning formal geometric concepts. This description of how children view shapes dominate in many later publication by Clements and his colleagues (Clements & Sarama, 2000, 2009), for they insist on describing the visual level as the level where children identify shapes based on their appearance:

At first children can't distinguish between on shape and another. Later, they can, but only visually- they recognize shapes as wholes. They might call a shape a "rectangle" because it looks like a door. They do not think about the defining attributes or properties of shapes. Not later, do students see relationships between classes of figures. For example, most children incorrectly believe that a figure is not a rectangle because it is not a rectangle because it is a square (Clements & Sarama, 2009, P.124) van Hiele (1957) described the method of geometric thinking using three aspects: the existence of levels, properties of the levels and the movement from one level to next level (Haviger & Vojkuvkova, 2013). According to the van Hiele there are five levels: Level 1 recognition (visualization), Level 2 analysis, Level 3 Order (abstraction), Level 4 deduction and Level 5 rigor. Usiskin (1982) tested the ability of the van Hiele model to describe and predict the performance of students in secondary school geometry. Each van Hiele level describes how children think about geometric concepts.

**Van Hiele Model of Geometric Thinking**

Originally van Hiele numbered them from 0 to 4, the USA introduced from 1 to 5; later Pierre van Hiele used only 3 levels. Moreover, also the level only vary at present (Haviger & Vojkuvkova, 2013). In this study the van Hiele level were discussed using the categories 1 to 5 by crowly and walle, (1987).

<u>Visualization</u>

Visualization is the stage at which geometric figures are recognized on the basis of their physical appearance as a whole rather than as having components or attributes. A child may be able to choose all the squares from a set of polygons by reasoning that they "look like squares." The child can compare or sort shapes on their appearance as a whole only

<u>Analysis</u>

At this level geometric concepts begin. The form of the figure recedes and the properties emerge. A child begins to identify relationships among parts of a figure.

The child will use a more proper vocabulary rather than completely her or his own. Given a set of polygons, the child can now sort them in a variety of ways depending upon a particular attribute. At this point, the child is ready to discover properties of figures and can solve geometric problems by using those properties, but s/he cannot explain those properties.

Informal Deduction

A child can now use the logic s/he was incapable of before. The child can now identify sets of properties that characterize a class of figures and test that these properties are sufficient to show that class. The child can now use informal arguments to answer questions. S/he can justify these arguments by use of diagrams, transformations of shapes, or other materials to physically show that these arguments are valid.

Deduction

Deduction is normally what is known as the high school Euclidean geometry course. Undefinedterms, definitions, and assumptions are now accepted by the student. S/he sees a formal definition and can prove relationships by use of theorems. The student is now capable of establishing a general principle that will unify several different theorems and can create a proof to support an argument.

Rigor

A student rigorously establishes theorems in different postulation systems and analyzes and compares these systems. Rigor is seldom reached in the high school setting. The student establishes theorems in different axiomatic systems and can compare these different systems.

**Learning Phases in van Hiele Theory**

According to van Hiele level 5 level of geometric thinking, each level involves there five phases. Van Hiele believes that cognitive progress in geometry can be accelerated by instruction. The progress from one level to next one is more dependent upon instruction than one age or maturity. They gave clear explanations of how teacher should proceed to guide students from one level to next.

Information or Inquiry

Students get the material and start discovering its structure. The teacher holds a conversation the pupils, in well-known language symbols, in which the context he wants to use becomes clear.

Guided or directed orientation

Students deal with tasks which help them to explore implicit relationships. The teacher suggests activities that enable students to recognize the properties of the new concept. The relations belonging to the context are discovered and discussed.

Explanation or Explication

Students formulate what they have discovered, and new terminology is introduced. They share their opinions on the relationships they have discovered in the activity. The teacher makes sure that the correct technical language is developed and used. The van Hiele thought it is more useful to learn terminology after students have had an opportunity to become familiar with the concept.

Free orientation

Students solve more complex tasks independently. It brings them to master the network of relationships in the material. They know the properties being studied, but they need to develop understanding of relationship in various situations. This type of activity is much more open-ended.

Integration

Students summarize what they have learned and keep it in mind. The teacher should give to the students an overview of everything they have learned. It important that the teacher does not present any new material during this phase, but only a summary of that has already been learned

**Conceptual Framework of the Study**

A conceptual framework is mental map which is makes by researcher to reach in goal. It is the representation of understanding of theories by researcher and her conceptualization of the relationship between variables. After the intensive study and analysis of empirical literature and theory, the researcher carried out framework, which is presented diagrammatically as follows:

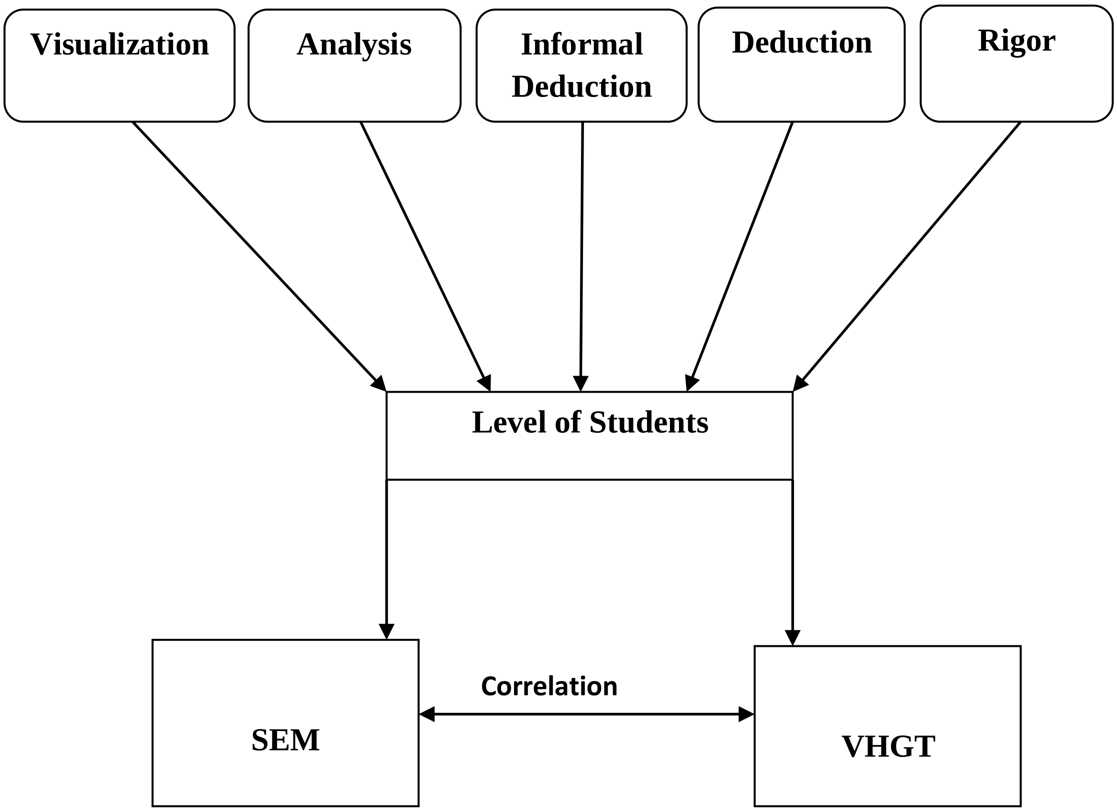



**Figure (2. 1): Relationship between VHGT and SEM**

The level of students in geometry associated with the level of visualization, analysis, informal deduction, deduction and rigor. The relation between VHGT and SEM are related with the level of students in geometry.

# Chapter III

# METHODS AND PROCEDURES

The chapter presents the methodology and procedure of the findings. This chapter describe in detail about research design, population, the method used in sample and sampling, tools, data collection procedure and data analysis procedure.

## Research Design

The research design depends upon the problems selected for the study. For this study, the researcher used mixed method research design. Mixed method research requires qualitative data and quantitative data both, the researcher had selected survey method in the research field to collect appropriate and sufficient data. Furthermore, students' van Hiele levels of thought and their achievement in mathematics were considered as the variables of the study.

## Population of the Study

According to Flash report-I there were 11,498 students studying at secondary level in the academic year 2073 B.S. Among them 6,220 were girls and 5,278 were boys students. All the secondary level mathematics students of grade X were the populations of the study.

## Sample of the Study

Since the survey was carried out at sample basis, the sample of this study was selected from Tanahun district by stratified random sampling method so as to good representation of the population. According to the District Education Office Tanahun, there are 157 secondary schools are running at thereference period. Furthermore the area was geographically divided into four strata: northern, southern, eastern, and western part of the district. One secondary level school from each part that is foursecondary level schoolswere selected.

**Table 3.1: Numbers of Boys and Girls students of selected schools**

| **Schools** | **First School** | | **Second School** | | **Third School** | | **Fourth School** | |
|---|---|---|---|---|---|---|---|---|
| **Gender** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** |
| **No.** | 19 | 24 | 27 | 25 | 26 | 31 | 22 | 29 |
| **Sub Total** | 43 | | 52 | | 57 | | 51 | |
| **Total** | **203** | | | | | | | |

There were all together 203 students of grade X comprising the sample of this study from the total school of Tanahun district. There were 109 girls and 94 boys students. The age of the participants ranged from 15 to 17, fourmathematics teachers, who were responsible for teaching mathematics of respective school. The list of the selected school has been given in Appendix-D.

**Data Collection Tools and Techniques**

In this study following tools were used for the data collections.

VHGT (van Hiele Geometric Test)

*Construction, Administration and Grading of VHGT*

*Construction:* VHGT was originally developed by the staff of CDASSG (Cognitive Development Achievement in Secondary School Geometry) project (Usiskin, 1982) assessing students' van Hiele level of geometric reasoning. Thus test consists of 25 multiple choice paper and pencil test with five purposed answer per items and five items per level. The researcher used only first 20 items that belongs to the first four van Hiele levels, because the students of grade 10 are not expected to reach level five. It is important to note that why the researcher chooses the VHGT but not other standardized test because every geometry question one asks is not assignable to a van Hiele level. The researcher adopted two questions from the VHGT developed by Atebe namely Q.N.5 and Q.N.16 to make the test relevant to Nepalese context (See Appendix-A). Also the English versions of these questions were translated in Nepali version thinking that students of public school would understand it easily.

*Administration:* In this study all the students who were participated, had to give answer in this test. The students were got their answer of the VHGT on multiple-choice answer sheets. Pilot testing was carried to indicate that this VHGT could complete in 30 minutes. 30 minutes have allowed the students to complete the VHGT. Thus with the help of mathematics teacher of sample school, the VHGT was administered by the researcher herself by visiting each participating school.

*Test Grading:* In VHGT two grading method was employed for the purpose of grading students. In first grading each was assign 1 point while, correct response of each 20 multiple choice question. So each students score range from 0-20 marks. And the second method of grading VHGT based on the "3 of 5 correct" success criterion suggested by Usiskin (1982,P.33). In this criterion, if a student answered at least 3 out of 5 items in any of the level, then the students would be considered to have a mastered on that level. Using this grading system developed by Usiskin (1982), the students were assigned weighted sum scores in the following manner:

1 point for meeting criterion on items 1-5 (level1)

2point for meeting criterion on items 6-10 (level2)

4point for meeting criterion on items 11-15 (level3)

8point for meeting criterion on items 16-20 (level4)

Thus, total points of students who can solve all problems are 15. Weighted sum determines upon which van level has been met. For example a score of 13 indicates the learner met the criterion at levels 1, 3 and 4 (i.e. 1+4+8). For a student to be assigned level 'n', he/she must satisfy the criteria not only at that level 'n' but also all preceding level 'n-1'. Thus a student who satisfied the criteria at level 1, 2, and 4 for instance would have no van Hiele level. And those students are said to be "no fit". Also those who are not classified to any VH level are classified as level 0. In 1990, two researchers (Clements and Batitista) hypothesized that a level exist that is below visualization. They called prerecognition level. Modified scheme was used because it gives a higher percentage of subjects that could be assigned a VH level i.e. it reduces the number of "no fit". Using this modified van Hiele levels ( i.e. 5 levels is excluded), the weighted sum and corresponding van Hiele levels are:

**Table 3.2: Modified van Hiele Levels and their Weighted Sums**

| Level | Corresponding Weighted sum |
|---|---|
| 0 | 0 |
| 1 | 1 |
| 2 | 3 |
| 3 | 7 |
| 4 | 15 |

**Achievement Test**

Achievement test refers to the School Examination in Mathematics (SEM). Theteacher of respective school was constructed, administrated and graded the test. Score of students were obtained from schools' record as a secondary data.

**Interview Schedule**

Interview is supplementary tool, which was conducted to get information concerning teachers' perception about van Hiele model of geometric thought. Interview was took with the teachers to get reflection or view of teacher of sample school about van Hiele geometric test and the performance of students on van Hiele level of geometric thinking with respect to the subject difficulty, level access, attitude toward geometry teaching, attitude toward training programme.

**Piloting of the Instrument**

The pilot study was carried out in 36 students of Shree Saraswoti Higher Secondary School, Mirlung. The result of the pilot study was discussed and analyzed with the supervisor. Moreover, the interview questions were made by the researcher according to her study, Interview schedule was used and necessary version and modification was made with the help of supervisor.

**Reliability of the Instrument**

To establish the reliability of the test, every test item was piloted before it was administered. Reliability refers to the consistency of ameasure. A test is considered reliable if we get the same result repeatedly. In present study, result of pilot study which summarized in the table as:

**Table 3.3: Numbers of Students at each VH level in piloting**

| van Hiele Level | N | % |
|---|---|---|
| 0 | 5 | 13.89 |
| 1 | 18 | 50 |
| 2 | 6 | 16.67 |
| 3 | 4 | 11.11 |
| 4 | 0 | 0 |
| Total fitting<br>No fit | 33<br>3 | 91.67<br>8.33 |
| **Total** | **36** | **100** |

Table 3.2 indicates that 5 (14%) of the 36 students who participated in the pilot study were found at the pre-recognition level. 18 (50%), 6 (17%) and 4 (11%) of the participants were respectively found at VH level 1, 2 and 3. None of participants at VH level 4, also 3 (8%) becomes no fit due to the random guessing of the given test. The table further shows that almost all of the participants were assignable to van Hiele levels of geometric reasoning using the 3 of 5 van Hiele modified theory.

Since the achievement test was not developed by the researcher because it was developed by respective teacher of participating school, this test was supposed to be valid. Furthermore the interview schedule was piloted and supposed the result with the supervisor and was found elicit desired information.

## Validation of the Instrument

Validation is an important key to effective research, if a piece of research is invalid then it is worthless. Therefore instrument used in this study was checked for validity. The documents analyzed were found to be valid because they were all consistent with the Nepalese education system. The van Hiele Geometric test was first developed by Usiskin (1982) to test the geometric reasoning of the American students. Atebe (2008) adopted this test for their study with the Nigerian and South African students. This study is similar to Atebe (2008) and Usiskin (1982). Therefore, researcher adopted test which was used by Atebe (2008). Knowing the adopted test was based on mathematics curricula of Nigeria and South Africa, the researcher piloted it in order to check for the suitability in the Nepalese context. The discussion had helped the researcher to determine the relevancy and validity of the test in the Nepalese context. VHGT was found valid because it was able to assess the students VH level.

**Data Collection Procedure**

In order to collect of data, the researcher visited sample school herself and met the head teacher and mathematics teacher of the school and explained the purpose of her test and then asksthe permission for administration of VHGT. The researcher made arrangement for the administration of the test and students were prepared for the test. Each school was visited and VHGT was administered during the period 2073-10-13 to 2073-10-21. The first to fourth school administered in 2073-10-13, 2073-10-17, 2073-10-18 and 2073-10-21 B.S. respectively. Students score in mathematic was obtained from the school’s records. The corresponding mathematics teachers were also asked to observe the item of test. And finally, they were interviewed to obtain their reflection about the test. After collecting the answer sheet the researcher checked carefully and scored according to the scoring scheme. And the score was transcribed in to computer.

**Data Analysis Procedure**

The calculated data were analyzed and interpreted using simple statistical techniques. Students score in each VH level was be added to obtain the total raw score. It was converted into percentage for the simplicity of comparison. Mean was used to find the level wise mean score of the students in VHGT and SEM. Furthermore, number of students in each van Hiele level was converted into percentage after that percentage number of students was interpreted in terms of their corresponding van Hiele level.

Karl Pearson’s coefficient of the correlation was used to find the relationship between students’ van Hiele level of geometric thinking and their achievement in mathematics. For this purpose students’ score in VHGT was correlated with their score in SEM. Only the score of those students who were classified into different van Hiele level was considered. The relation was desired between van Hiele level and achievement in mathematics. Also the students who were functioning at pre-recognition level were not taking into account for the calculation for; if, their VH score was ‘0’. In order to test the significance of the coefficient of the correlation, probable error of (r) was calculated and interpreted. The data from the interview of respective teacher were analyzed and interpreted according to van Hiele.

# Chapter IV

## ANALYSIS AND INTERPRETATION OF DATA

This chapter deals with the analysis and interpretation of the data which is the central of the data of the whole research. This is the survey type of research which was taken to find out the relationship between students' van Hiele level of thought and their achievement in mathematics. The data was collected from the students of grade X of Tanahun district of academic year 2073 B.S. The data were obtained from the School Examination of Mathematics and VHGT were collected, tabulated and analyzed. The data collected were analyzed under the heading of Students' van Hiele level of geometric thought, correlation between the students' van Hiele level of thought and their achievement in mathematics and teachers' reflection about the VHGT.

### Students' van Hiele level of Geometric Thought

According to the VH level classification assignment method the students' performance on VHGT was analyzed in order to determine the number and percentage of students at each van Hiele level, where '3 of 5 correct' success criterion was used in classification methods. The score of students on VHGT has been given in Appendix E. The result is summarized in the Table 4.1.

**Table 4.1**

**Numbers of Students at each VH level of Geometric Reasoning**

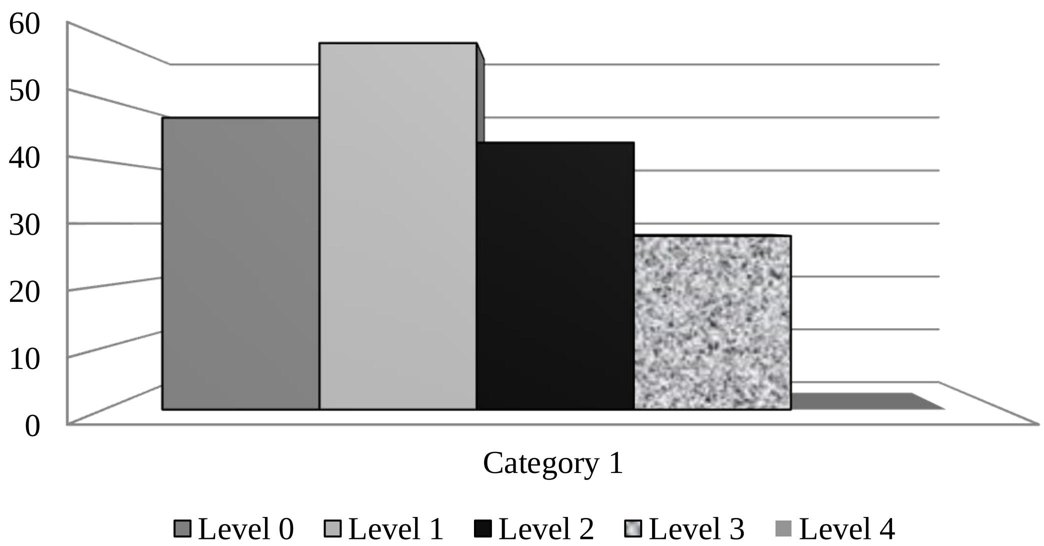
| **VH Level** | **No. of Students** | **Percentage** |
|---|---|---|
| 0 | 47 | 23.15 |
| 1 | 59 | 29.06 |
| 2 | 43 | 21.18 |
| 3 | 28 | 13.79 |
| 4 | 0 | 0 |
| Total fitting | 177 | 87.19 |
| No fitting | 26 | 12.81 |
| **Total** | **203** | **100** |

Table 4.1 shows that 47 (23.15%) students are below the van Hiele level 1. Out of 203 students were still functioning at recognition level. This implies that they are at level 0. Likewise, out of 203 students 59 (29.06%) and 43 (21.18%) students are at visual and analysis level, are VH level 1 and 2 respectively. It also indicates that 28 (13.79%) students are at van Hiele level 3. At level 3 most of the problems are seems quite difficult than problems at VH 1 and 2 and learners in this level had difficulty in dealing with concerning class inclusion and the relationships between the properties of various simple geometric shapes and between different shapes.

The table shows that no students reasoning at deduction level. In other words no students attain the VH level 4. This study shows that even some students present proof of a theorem though they don't understand it fully. This fact even some students construct a formal proof of a theorem they do not understand it well. It justifies students of grade 10 are not of capable of understanding the meaning of axioms, postulates , meaning of converse and sufficient condition, role of undefined terms, definition of theorem as a way of establishing geometric theorems with as axiomatic systems (Usiskin,1982).

Furthermore, the table indicates that using the modified van Hiele level assignment scheme a total of 177 (87.19%) learners were assignable at various van Hiele levels, while 26 (12.81%) of them did not fit this classification scheme.

**Figure 4.1: Number of Students at Different VH Levels**




From above chart 4.1 shows that most of the students are at stage of visualization, where they only recognized the geometric figures and shape with their physical appearance rather than as having components of attributes. And also the figure shows that many students were at low van Hiele geometric thinking. They couldn't distinguish between geometric shapes like square and rectangles, square and rhombus, rhombus and quadrilateral etc. The task of recognizing and starting the name of shapes (VH level 1) was easier than that of the listing the discerning properties of shape. This also reveals that the number of students decreases as they proceed to the items of the higher level.

**Correlation between the Students' van Hiele Level of Geometric thought and their Achievement in Mathematics**

In this section, it concerned with the determination of the possible relationship that might exist between van Hiele level and mathematical achievement of participatory students. After students assigned with different VH levels, their total VH level was calculated and then the corresponding percentage mean score was computed. Also the score in school examination in mathematics was obtained in percentage. Additionally, each student's weighted sum was taken in to consideration for the purpose of finding correlation.

**Table 4.2: Number of students in each VH level with their Percentage Means score in VHGT and SEM**

| VH level | No. of Students | % Mean Score in VHGT | % Mean Score in SEM |
|---|---|---|---|
| 0 | 47 | 24.04 | 38.21 |
| 1 | 59 | 32.29 | 40.56 |
| 2 | 43 | 44.07 | 52.67 |
| 3 | 28 | 60.71 | 77.29 |
| 4 | 0 | 0 | 0 |
| Overall percentage mean score in VHGT = 32.22 | | | |

Table 4.2 shows that the percentage mean score of 47 students in VHGT who were at '0' VH level (prerecognition) is 24.04. Similarly, the mean scores of students in VHGT who were at 1, 2, 3 and 4 are 32.29, 44.047, 60.71, and 0 respectively.

Likewise, their percentage means score in SEM are 38.21, 40.56, 52.67, 77.29 and 0 respectively. This shows that with the increase of VH level of students their score in SEM increase. Thus the strong correlation between VHGT and SEM (r=0.71) indicated that there was a relationship between achievement in mathematics and advancement in the van Hiele level of understanding geometry.

After tabulated the data, correlation coefficient was calculated to determine the relationship between students' van Hiele geometric reasoning and their achievement in mathematics.

**Table 4.3: Calculated VHGT and SEM scores and their Correlation**

| **No. of Students** | **VHGT** | **SEM** | | | | | |
|---|---|---|---|---|---|---|---|
| **N** | $\sum x$ | $\sum y$ | $\sum xy$ | $\sum x^2$ | $\sum y^2$ | **r** | **P.E.** |
| 130 | 388 | 6830 | 23879 | 1828 | 394786 | 0.71 | 0.029 |

The Pearson's product moment correlation coefficient was used for finding the correlation from the score obtained by students in VHGT and SEM which has been given in the Appendix-E. The correlation coefficient found to be 0.71. Hence it can be said that there is highly positive correlation between students' van Hiele level of geometric thought and its relationship to their achievement in mathematics.

In order to ascertain the significance of Pearsonian correlation coefficient, the probable error of coefficient of correlation P.E. (r) is calculated (See Appendix-B). It was 0.029 so, the value of $\rho(=0.71)$ is greater than 6 times of probable error $(6\times0.029)$ i.e. $\rho>6$P.E. So r is definitely significant. This implies that there is strong correlation between the students, VH level and their achievements in mathematics.

**Teachers' Reflection about VHGT**

This section deals with teacher attitude towards mathematics teaching and learning activities, their experience of teaching geometry and knowledge about van Hiele theory. Teacher's knowledge about content and teaching learning theories related to the subject is the most important factors for enhancing students learning. The students' level of thinking in geometry analyze in this section. For this researcher asked the questions to the teachers from the interview schedule, then she notes their responses (see: appendix C). In this study four mathematics teachers were selected. All the teachers' interviewed were three male and one female. All of them were trained in mathematics teaching but none of them had any special training in teaching geometry. All of them were graduated. At the end of VHGT test of each school's teachers were interviewed by researcher herself. This study tried to find out the van Hiele's level of geometric thought with respect to the subject difficulty, level access, attitude toward geometry teaching and attitude toward training programme.

In response of first teacher's, "I have got in service teacher training for ten months, training helps us for making and using the teaching materials and technology of how to teach geometry. Geometry teaching is always challenging to mathematics teachers and there is no difficulty in content of geometry but there is difficulty in drawing, constructing pictures and logically reasoning due to lack of teaching materials, teachers' guide and good training. Geometry teaching is very easy when our students are good in previous lessons. van Hiele model of geometric thinking is a model which is very useful in geometry teaching, but I have no clear idea on it".

In response of second teacher's "I have got in service teacher training for ten months, it gives us new technology, methods, way to teach students properly and it also help us to make materials. Training helps to improve the classroom teaching. Geometry is an interesting subject; it helps to solve the daily life problems.In geometry teaching we should used local and low –cost materials. Students are not poor in geometry so we should teach as their achievement level. So it is very important that mathematics teacher should know about their student's level. Van Hiele level of geometric thought is theory developed by two mathematicians, may be they were husband and wife. It describes the level wise progress of student's geometrical knowledge. The method and teaching procedure is easy in level '0','1','2' than level '3' and '4'".

In response of third teacher "I have got in service teacher training for ten months and it is the backbone of teaching field. It helps us for making materials, techniques of teaching and classroom management.Geometry is very useful in every field of human life. It is possible that using successful teaching methodologies to enhance the understanding of students' learning geometry will help their own knowledge.Teacher need to accept students' ideas as central knowledge in mathematics in order to develop their own personnel teaching approaches. Lecture method is insufficient for geometry teaching and if we go through the van Hiele theory then teaching is more effective than we usually used. So van Hiele theory is very useful in effective learning geometry".

In response of fourth teacher's "I have got TPD training with three stages, it provided us to learn the teaching techniques as well as the language of instruction. Training programme made us believe in our capability and believe that mathematics subject is an interesting subject, not a difficult subject. I have enough knowledge of mathematics teaching in secondary level. I have learned van Hiele model of teaching geometry. It is a geometric teaching theory, related with students' level of understanding. It is very useful method than conventional method. There are five levels; first three level are easy than last two level. If we teach the concept of geometric ideas basically and level wise, the students go through first level to last level easily. Lecture method is insufficient for mathematics teaching mathematics so we should go through the discovery method.

After all responses of teachers', the researcher concludes that teachers' view on training are positive and training helps to teaching constructing the materials with new method. Most of the students seem confuse on learning geometry because of proper teaching materials and methods and also the students prior attainments, which causes difficulty in learning geometry. This made students no fit in level wise learning of geometry. The researcher found that three of the teachers have knowledge about van Hiele theory and they expressed teaching procedure is not difficult in level visualization, analysis and informal deduction than in level deduction and rigor level.

VHGT is one of the models of teaching geometry, which helps to students in level wise progress on geometrical learning. It was somehow different model for the teacher and they become familiar about VHGT method. In analysing the data, it was very necessary to understand in depth, the nature of each phase in the Van Hiele Model. Pierre van Hiele (1986, p177) suggested that the teacher conduct the teaching process as follows: in the first phase, “by placing at the children’s disposal (putting into discussion) material clarifying the context”; in the second phase, by supplying the material by which the pupils learn the principal connection in the field of thinking”; in the third phase, “by leading class discussions that will end in a correct use of language”; in fourth phase,“by supplying materials with various possibilities of use and giving instructions to reflect on their actions, by having rules composed and memorized, and so on”. This illustrates that, as a teacher move through the teaching phases, there is a transition from forms of direct instruction towards the students’ independence from the teacher.

# Chapter- V

# FINDINGS, CONCLUSIONS AND RECOMMDATIONS

This chapter deals with the summary, findings, conclusions and recommendations of the study. After the rigorous analysis and interpretation of collected data, summary and findings of the study have been derived and conclusion has been made on the basis of the findings. The recommendations for further research are forwarded.

This was mixed method research design. Its main aim was to investigate the X grade students van Hiele level of geometric thought and exploring the relationship with their mathematics achievements. In order to achieve the objectives, the researcher selected 4 schools fromTanahun district using stratified random sampling method.  The total of 203 students who were available at the visited time constituted the sample of this study. In order to assess the students van Hiele level, adopted version of VHGT developed by the staff of CDASSG project was employed as main research tool. This test was administered by visiting each school by the researcher herself with cooperation of the teacher of the participating school. Also, the score of SEM of those students who were participated in VHGT was obtained from the respective schools' record. And, then the score scored by these students was analyzed and obtained the following finding.

## Findings of the Study

The aim of the research was to find out the relation between students' van Hiele level of thought and achievement of school Examination of half yearly test of selected schools. On the basis of analysis of data and interpretation of result, the following objective wise findings have been derived.

1. An overall percentage mean score of 32.22% obtained by the participating students in VHGT was regarded as evidence that the majority of the learners in this study were at low van Hiele geometric thinking levels (possibly 0, 1or 2).
2. The result of this study indicated that the absence of students at level 4 and only few students were at level 3, implies that most of them didn't possess the experience necessary of the formal study of secondary school geometry. Also, the result indicated that the majority of the students who took VHGT were at level 0 on the van Hiele geometric scale, which implies their knowledge of school was poor.
3. These result, in addition to proving support for the hierarchical properties of the van Hiele level also indicated that students in this study experienced more difficulty with geometry problems typifying van Hiele level 3 reasoning than problems associating with theother levels.
4. Students' VHGT scores were found to be significantly correlated with their SEM scores. That means there is strong relationship between students' achievement in mathematics and their van Hiele level. This means that who did well in the VHGT did just as well in the school mathematics examination.
5. Three of respondents found that method and teaching procedure is easy in level '0', '1' and '2' than level '3' and '4'.
6. All the respondents reflected positive attitude towards geometry teaching with new methodology. Students' lower classes insufficient achievement in geometry gets confused to the students on learning geometry.

7. All respondents found that there is difficulty on subject matter due to lack of teaching materials and proper training of new technology about teaching geometry.

**Conclusions**

This study shows that the students at grade 10 were not adequately prepared to understanding the concept of geometry. On the basis of findings the conclusion can be drawn significantly about relation between van Hiele geometric thought and achievement in mathematics. This research indicates that the van Hiele theory can be a way of characterising the teaching phases in geometrical proof. Due to lack of knowledge about van Hiele theory, many issues remain unclear, including how the phases of teaching relate to the subject matter. The phases of students' prior attainment, are followed whether in a linear way or a iteratively within a topic or even included within on sequence of teaching phases or in different way depending on particular phases what is being taught. All these considerations mean that further study is essential if explanations of how effectively teachers support student in their geometric thinking and proving.

Most of the students of this study were between the VH levels 2, which indicate that secondary level students' geometric knowledge is poor. They have poor conceptual understanding in geometry possibly due to their emphasis in mechanical and procedural learning. The relationship between VHGT and SEM isstrong. The poor performance of lower level of van Hiele was strongly associated with being on mathematics, which reveals that the students levels of geometric thinking plays vital role in the learning of mathematics.

Also, this study revealed that van Hiele level of thinking is model, which helps to the students to achieve the geometric knowledge consequently and saves in each levels knowledge also knowledge of previous one. This VHGT levels shows that van Hiele level of thinking is a theory which is very useful to determine student's geometric reasoning. Also, claims that VHGT is one of the most important tools to find out the achievement of students in geometry and supports van Hiele theory is one of the best framework in exploring students' geometric reasoning.

**Recommendations**

On the basis of the findings derived from the analysis and interpretation of the data, the following recommendations have been given:

1. Since most of the students in this study was found below VH level 2, which shows they need systematic geometric concept of primary and lower secondary level before secondary level.
2. All most all of the students subjected to this research got successful to identify shapes only in standard sketch. So teacher is required to provide students with great opportunities for teaching the properties of geometric shapes in different sketches and angles. The different should emphasize the constant properties of shapes during this research.
3. Universities and institution having authority and responsibility for yielding school level mathematics teacher should include the knowledge about van Hiele theory to the mathematics teacher.
4. Teacher being aware of the level of thinking that characterize each of the van Hiele levels may assist greatly the complexity between the teaching methods and teacher's cognitive thinking level.

5. Since van Hiele theory forms the foundation of mathematics curriculum for country such as USA Britain Netherlands Russia etc. (Mateya P.106), so it is suggested that Nepalese mathematics should also be aligned itself with the van Hiele theory.

**Suggestion for the further Study**

The following suggestions have been found by the researcher for further study:

1. This study was subjected to $10^{th}$ class students of Tanahun District. So, further students can be done in different classes of the related in different districts of Nepal and the outcome of the research can be generalized.
2. This study can be carried out in lower secondary level, primarily level and other grade of level.
3. A research can be carried out to find out the whether the Nepalese mathematics curricula are aligned with van Hiele theory or not.
4. It would be worthwhile to study whether the instructional phases mentioned by van Hiele are effective in promoting students VH level in this Nepalese scenario.
5. During the research, just paper pencil test namely VHGT test was employed to determine the students van Hiele level. It was also recommended that clinical interview; hands on activity along with VHGT can be employed to assess the students' researching level. The data collected thus from there different tools can be triangulated to assign students VH level more accurately.

6. It would be worthwhile to explore in the light of van Hiele theory, whether the class room rules in schools are being followed or not by using checklist of VH phase descriptor.

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## Appendix A -1

**English Version of VHGT**

**Van Hiele Geometry Test (VHGT)**

Instructions

1. Do not start until you are told to do so.
2. While you are waiting, please fill the appropriate information in the spaces below.

   Name:

   Name of the school:

   Grade:

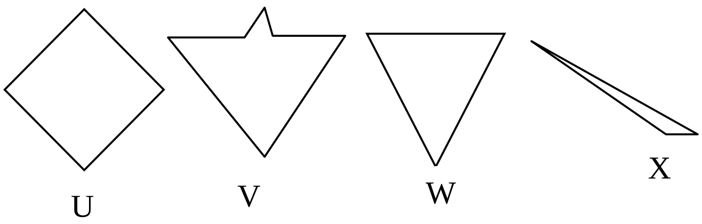
   Age (in years): Sex: Boy ☐ Girl ☐

3. This is an objective test, consisting of 20 multiple-choice questions. Each question is followed by five options lettered A to E. There is only one correct answer to each question. Read each question carefully and tick (✓) the correct answer.

English Version of VHGT

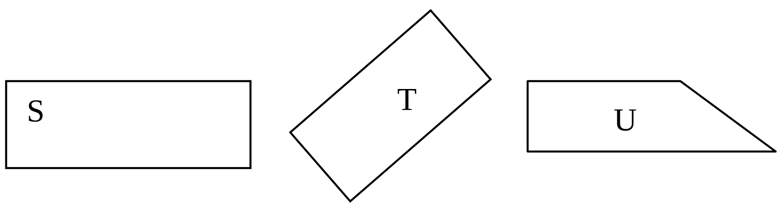
Time: 30 minutes

1. Which of these are triangles?




   a) None of these are triangle
   b) V only
   c) W only
   d) W and X only
   e) V and W only

2. Which of these are rectangles?




   a) S only
   b) T only
   c) S and T only

d) S and U only

e) All are rectangles

3. Which of these are squares?

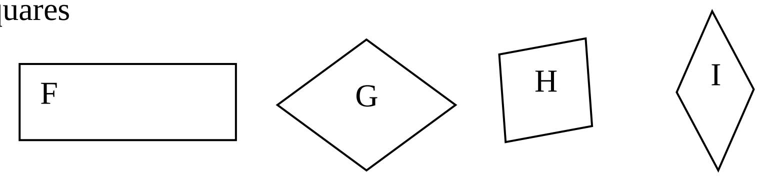
a) None of these are squares

b) G only

c) F and G only

d) G and I only

e) All are squares




4. Which of these are quadrilaterals?

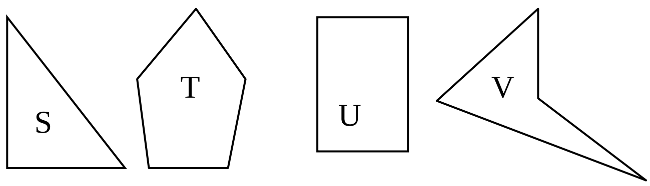
a) None of these are quadrilaterals

b) U only

c) U and V only

d) S and T only

e) S and V only




5. Which of these are parallelograms?

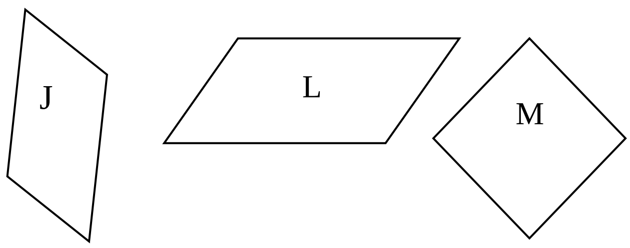
a) J only

b) L only

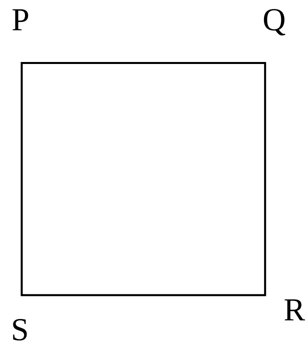
c) J and M only

d) None of these are parallelograms

e) All are parallelograms




6. PQRS is a square. Which relationship is true in all squares?




a) PR and RS have the same length.

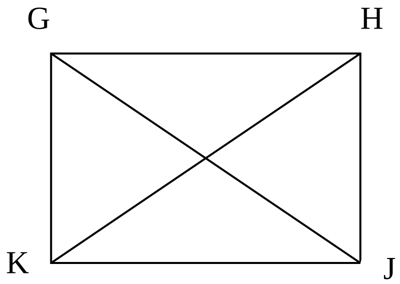
b) QS and PR are perpendicular.

c) PS and QR are perpendicular.

d) PS and QS have the same length.

e) Angle Q is larger than angle R.

7. In a rectangle GHJK, GJ and HK are the **diagonals**. Which of (A) – (D) is **not true** in every rectangle?




a) There are four right angles.

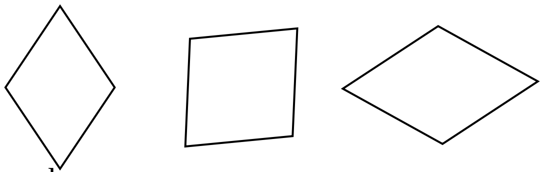
b) There are four sides.

c) The diagonals have the same length.

d) The opposite sides have the same length.

e) All of (A) – (D) are true in every rectangle.

8. A **rhombus** is a 4 sided figure which all sides of same length. Here are three examples. Which of (A) – (D) is **not true** in every rhombus?



a) The two diagonals have the same length.

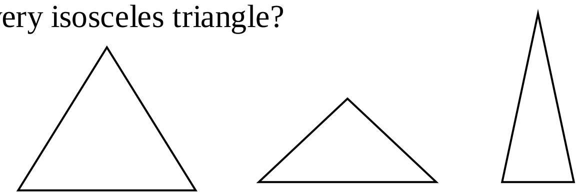
b) Each diagonal bisects two angles of the rhombus.

c) The two diagonals are perpendicular.

d) The opposite angels have the same measure.

e) All of (A) – (D) are true in every rhombus.

9. An isosceles triangle is a triangle with two sides of equal length. Here are three examples. Which of (A) – (D) is true is every isosceles triangle?



a) The three sides must have the same length.

b) One side must have twice the length of another side.

c) There must be at least two angles with the same measure.

d) The three angles must have the same measure.

e) None of (A) – (D) is true in every isosceles triangle.

10. Two circles with centres P and Q intersect at R and S to form a 4 sided figure PQRS. Here are two examples. Which of (A) – (D) is not always true?

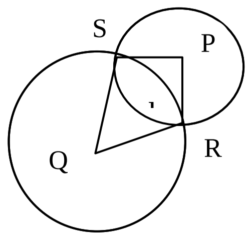
a) PRQS will have two pairs of sides of equal length.

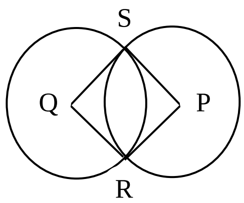
b) PRQS will have at least two angles of equal measure.

c) The lines PQ and RS will be perpendicular.

d) Angles P and Q will have the same measure.

e) All of (A) – (D) are true.




11. Here are two statements.

Statement 1: Figure F is rectangle.

Statement 2: Figure F is triangle.

Which is correct?

a) If 1 is true, then 2 is true.

b) If 1 is false, then 2 is true.

c) 1 and 2 cannot both be true.

d) 1 and 2 cannot both be false.

e) None of (A) – (D) is correct.

12. Here are two statements.

Statement S: △ABC has three sides of the same length.

Statement T: In △ABC, ∠B and ∠C have the same measure.

Which is correct?

a) Statements S and T cannot both be true.

b) If S is true, then T is true.

c) If T is true, then S is true.

d) If S is false, then T is false.

e) None of (A) – (D) is correct.

13. Which of these can be called rectangles?

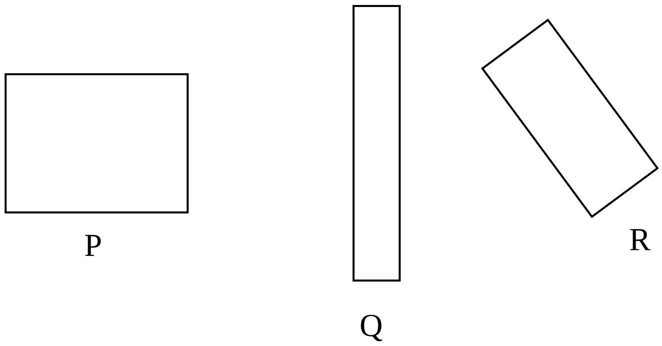
a) All can

b) Q only

c) R only

d) P and Q only

e) Q and R only




14. Which is true?

a) All properties of rectangles are properties of all squares.

b) All properties of squares are properties of all rectangles.

c) All properties of rectangles are properties of all parallelograms.

d) All properties of squares are properties of all parallelograms.

e) None of (A) – (D) is true.

15. What do all rectangles have that some parallelograms do not have?

a) Opposite sides equal

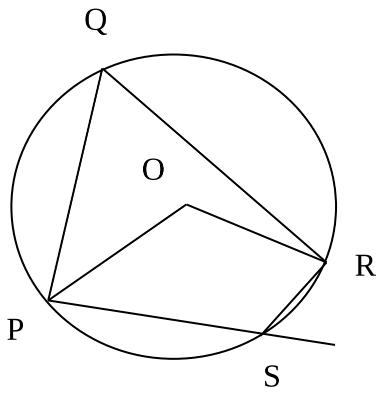
b) Diagonals equal

c) Opposite sides parallel

d) Opposite angles equal

e) None of (A)-(D) is true

16. PQRS is a cyclic quadrilateral. O is the centre of the circle. Line PS is produced to a point T, outside the circle.




From this diagram, one can prove that ∠Q = ∠RST. What would you conclude from this proof?

a) Given any cyclic quadrilateral PQRS which PS produced to T, then ∠Q = ∠RST.

b) Only in this cyclic quadrilateral can we be sure that angle ∠Q = ∠RST.

c) Given any quadrilateral, PQRS with PS produced to T, then ∠Q = ∠RST.

d) Only when the quadrilateral PQRS looks like a kite can we be sure that ∠Q = ∠RST.

e) Only in some, but not all cyclic quadrilateral PQRS, can we prove that ∠Q = ∠RST.

17. Here are three properties of figure.

Property D: It has diagonals of equal length.

Property S: It is a square.

Property R: It is a rectangle.

Which is true?

a) D implies S which implies R.

b) D implies R which implies S.

c) S implies R which implies D.

d) R implies D which implies S.

e) R implies S which implies D.

18. Here are two statements.

I: If a figure is a rectangle, then its diagonals bisect each other.

II: If diagonals of a figure bisect each other, the figure is a rectangle.

Which one is correct?

a) To prove I is true, it is enoug

b) To prove II is true, it is enough to prove that I is true.

c) To prove II is true, it is enough to find one rectangle who diagonals bisect each other.

d) To prove II is false, it is enough to find one non-rectangle whose diagonals bisect each other.

e) None of (A) – (D) is correct.

19. In geometry:

a) Every term can be defined and every true statement can be proved true.

b) Every term can be defined but it is necessary to assume that certain statements are true.

c) Some terms must be left undefined but every true statement can be proved true.

d) Some terms must be left undefined and it is necessary to have some statements which are assumed true.

e) None of (A) – (D) is correct.

20. Examine these three sentences.

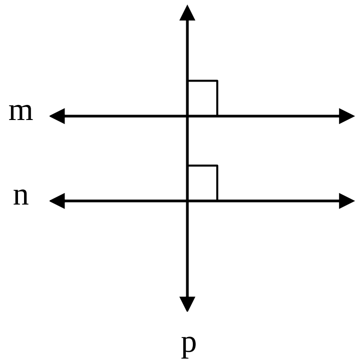
(1) Two lines perpendicular to the same line are parallel.

(2) A line that is perpendicular to one of two parallel lines is perpendicular to the other.

(3) If two lines are equidista

In the figure below, it is given that lines m and p are perpendicular and lines n and p are perpendicular. Which of the above sentences could be reason that line m is parallel to line n?

a) 1 only
b) 2 only
c) 3 only
d) Either 1 or 2
e) Either 2 or 3




**The End**

## Appendix B

## CALCULATION OF CORRELATION COEFFICIENT

$\sum x = 388$

$\sum y = 6830$

$\sum xy = 23879$

$\sum x^2 = 1828$

$\sum y^2 = 394786$

N = 130

$$r = \frac{N\sum xy - \sum x \sum y}{\sqrt{N\sum x^2 - \left(\sum x\right)^2}\sqrt{N\sum y^2 - \left(\sum y\right)^2}}$$

$$= \frac{130 \times 23879 - 388 \times 6830}{\sqrt{130 \times 1828 - 388^2}\sqrt{130 \times 394786 - 6830^2}}$$

= 0.71

Test of Significance

P.E. (r) = $0.6745 \dfrac{1 - r^2}{\sqrt{N}}$

P.E. (r) = $0.6745 \dfrac{1 - 0.712^2}{\sqrt{130}} = 0.029$

6×P.E.(r) = 6×0.029=0.175

And 0.71>0.175

Thus r > 6 P.E. (r)

## Appendix C

## INTERVIEW SCHEDULE FOR TEACHER

1. School:
2. Teacher's Name:
3. Gender: Male Female
4. Teaching qualification

Q.N.1. How long have you been teaching mathematics?

Q.N.2. Have you had any training in teaching geometry?

Q.N.3. What do you feel in teaching geometry? And why?

Q.N.4. Do you know anything about van Hiele model of geometry thinking?

Q.N.5. Is there difference on VHGT in comparison to usual test of School?

Q.N.6. What kinds of problems do you face during teaching geometry?

Q.N.7. Do you think that students studying at secondary level come from the lower classes without sufficient experience in geometry?

# Appendix D

## LIST OF SHCOOL SELECTED FOR STUDY

1. Ram Shah Higher Secondary School, Aanboo Khaireni, Tanahun
2. Mitrata Secondary School, Satrasaya, Tanahun
3. Shree Pabitra Hiegher Secondary School, Bandipur, Tanahun
4. Shree Bishnu Secondary School, Ghasikuwa, Nahala, Tanahun

**Appendix E**

**STUDENTS' PERFORMANCE ON VHGT and SEM**

| Students | Raw Score in each VH Level | | | | Total Score | % Score | Weighted Sum Score | Assigned VH Level | Score in SEM |
|---|---|---|---|---|---|---|---|---|---|
| S.N | 1 | 2 | 3 | 4 | | | | | |
| 1 | 5 | 3 | 1 | 1 | 10 | 50 | 3 | 2 | 65 |
| 2 | 3 | 3 | 2 | 2 | 10 | 50 | 3 | 2 | 45 |
| 3 | 4 | 0 | 0 | 1 | 5 | 25 | 1 | 1 | 35 |
| 4 | 3 | 3 | 1 | 0 | 7 | 35 | 3 | 2 | 51 |
| 5 | 2 | 2 | 1 | 1 | 6 | 30 | 0 | 0 | 46 |
| 6 | 3 | 3 | 3 | 1 | 10 | 50 | 7 | 3 | 72 |
| 7 | 3 | 0 | 0 | 1 | 4 | 20 | 1 | 1 | 38 |
| 8 | 2 | 1 | 3 | 1 | 7 | 35 | 4 | * | 37 |
| 9 | 4 | 0 | 0 | 1 | 5 | 25 | 1 | 1 | 42 |
| 10 | 3 | 3 | 3 | 0 | 9 | 45 | 7 | 3 | 45 |
| 11 | 5 | 4 | 3 | 1 | 13 | 65 | 7 | 3 | 88 |
| 12 | 3 | 2 | 0 | 2 | 7 | 35 | 1 | 1 | 45 |
| 13 | 4 | 3 | 2 | 3 | 12 | 60 | 11 | * | 41 |
| 14 | 3 | 2 | 3 | 0 | 8 | 40 | 5 | * | 37 |
| 15 | 3 | 1 | 0 | 1 | 5 | 25 | 1 | 1 | 40 |
| 16 | 4 | 3 | 3 | 1 | 11 | 55 | 7 | 3 | 70 |
| 17 | 3 | 1 | 0 | 0 | 4 | 20 | 1 | 1 | 32 |
| 18 | 4 | 1 | 1 | 3 | 9 | 45 | 9 | * | 45 |
| 19 | 2 | 1 | 0 | 0 | 3 | 15 | 0 | 0 | 35 |
| 20 | 2 | 2 | 2 | 0 | 6 | 30 | 0 | 0 | 36 |
| 21 | 4 | 3 | 3 | 2 | 12 | 60 | 7 | 3 | 85 |
| 22 | 4 | 1 | 1 | 0 | 6 | 30 | 1 | 1 | 39 |
| 23 | 4 | 3 | 3 | 1 | 11 | 55 | 7 | 3 | 69 |
| 24 | 3 | 2 | 2 | 2 | 9 | 45 | 1 | 1 | 35 |
| 25 | 4 | 4 | 3 | 2 | 13 | 65 | 7 | 3 | 77 |
| 26 | 3 | 3 | 0 | 1 | 7 | 35 | 3 | 2 | 32 |
| 27 | 3 | 1 | 3 | 1 | 8 | 40 | 5 | * | 38 |
| 28 | 2 | 2 | 0 | 0 | 4 | 20 | 0 | 0 | 32 |
| 29 | 2 | 3 | 0 | 1 | 6 | 30 | 2 | * | 35 |
| 30 | 3 | 0 | 2 | 1 | 6 | 30 | 1 | 1 | 32 |
| 31 | 5 | 3 | 1 | 1 | 10 | 50 | 3 | 2 | 40 |
| 32 | 3 | 1 | 2 | 1 | 7 | 35 | 1 | 1 | 35 |
| 33 | 5 | 4 | 3 | 0 | 12 | 60 | 7 | 3 | 76 |
| 34 | 4 | 2 | 2 | 2 | 10 | 50 | 1 | 1 | 45 |
| 35 | 2 | 2 | 1 | 2 | 7 | 35 | 0 | 0 | 40 |
| 36 | 4 | 2 | 0 | 0 | 6 | 30 | 1 | 1 | 43 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 37 | 3 | 1 | 1 | 0 | 5 | 25 | 1 | 1 | 32 |
| 38 | 4 | 3 | 1 | 1 | 9 | 45 | 3 | 2 | 38 |
| 39 | 4 | 1 | 0 | 2 | 7 | 35 | 1 | 1 | 35 |
| 40 | 3 | 1 | 1 | 0 | 5 | 25 | 1 | 1 | 32 |
| 41 | 4 | 3 | 3 | 1 | 11 | 55 | 7 | 3 | 54 |
| 42 | 3 | 1 | 2 | 0 | 6 | 30 | 1 | 1 | 40 |
| 43 | 4 | 3 | 3 | 1 | 11 | 55 | 7 | 3 | 69 |
| 44 | 4 | 3 | 3 | 1 | 11 | 55 | 7 | 3 | 59 |
| 45 | 3 | 1 | 2 | 1 | 7 | 35 | 1 | 1 | 46 |
| 46 | 4 | 0 | 1 | 1 | 6 | 30 | 1 | 1 | 35 |
| 47 | 3 | 2 | 1 | 0 | 6 | 30 | 1 | 1 | 41 |
| 48 | 3 | 3 | 0 | 2 | 8 | 40 | 3 | 2 | 54 |
| 49 | 3 | 1 | 1 | 0 | 5 | 25 | 1 | 1 | 32 |
| 50 | 3 | 1 | 2 | 0 | 6 | 30 | 1 | 1 | 35 |
| 51 | 4 | 3 | 1 | 0 | 8 | 40 | 3 | 2 | 66 |
| 52 | 5 | 2 | 2 | 2 | 11 | 55 | 1 | 1 | 73 |
| 53 | 3 | 3 | 2 | 3 | 11 | 55 | 0 | 0 | 40 |
| 54 | 4 | 1 | 1 | 1 | 7 | 35 | 1 | 1 | 39 |
| 55 | 4 | 0 | 0 | 3 | 7 | 35 | 9 | * | 51 |
| 56 | 3 | 3 | 1 | 0 | 7 | 35 | 3 | 2 | 56 |
| 57 | 3 | 3 | 1 | 1 | 8 | 40 | 3 | 2 | 42 |
| 58 | 2 | 2 | 0 | 1 | 5 | 25 | 0 | 0 | 34 |
| 59 | 3 | 3 | 1 | 2 | 9 | 45 | 3 | 2 | 61 |
| 60 | 4 | 3 | 3 | 1 | 11 | 55 | 7 | 3 | 78 |
| 61 | 2 | 2 | 0 | 1 | 5 | 25 | 0 | 0 | 36 |
| 62 | 4 | 3 | 0 | 1 | 8 | 40 | 3 | 2 | 57 |
| 63 | 3 | 3 | 1 | 2 | 9 | 45 | 3 | 2 | 48 |
| 64 | 4 | 2 | 2 | 1 | 9 | 45 | 1 | 1 | 59 |
| 65 | 4 | 3 | 2 | 2 | 11 | 55 | 3 | 2 | 82 |
| 66 | 3 | 2 | 2 | 0 | 7 | 35 | 1 | 1 | 35 |
| 67 | 3 | 1 | 1 | 1 | 6 | 30 | 1 | 1 | 32 |
| 68 | 4 | 1 | 3 | 0 | 8 | 40 | 5 | * | 40 |
| 69 | 3 | 2 | 1 | 1 | 7 | 35 | 1 | 1 | 36 |
| 70 | 3 | 3 | 1 | 1 | 8 | 40 | 3 | 2 | 59 |
| 71 | 2 | 1 | 0 | 1 | 4 | 20 | 0 | 0 | 32 |
| 72 | 1 | 1 | 1 | 0 | 3 | 15 | 0 | 0 | 32 |
| 73 | 5 | 1 | 2 | 0 | 8 | 40 | 1 | 1 | 38 |
| 74 | 4 | 3 | 2 | 1 | 10 | 50 | 3 | 2 | 65 |
| 75 | 2 | 2 | 2 | 2 | 8 | 40 | 0 | 0 | 32 |
| 76 | 2 | 2 | 1 | 1 | 6 | 30 | 0 | 0 | 40 |
| 77 | 5 | 4 | 3 | 1 | 13 | 65 | 7 | 3 | 94 |
| 78 | 1 | 1 | 1 | 1 | 4 | 20 | 0 | 0 | 38 |
| 79 | 3 | 2 | 1 | 0 | 6 | 30 | 1 | 1 | 38 |
| 80 | 2 | 1 | 1 | 0 | 4 | 20 | 0 | 0 | 39 |
| 81 | 1 | 0 | 1 | 1 | 3 | 15 | 0 | 0 | 32 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 82 | 4 | 2 | 1 | 0 | 7 | 35 | 1 | 1 | 47 |
| 83 | 3 | 2 | 1 | 1 | 7 | 35 | 1 | 1 | 48 |
| 84 | 5 | 3 | 1 | 0 | 9 | 45 | 3 | 2 | 61 |
| 85 | 3 | 2 | 0 | 1 | 6 | 30 | 1 | 1 | 41 |
| 86 | 4 | 3 | 1 | 0 | 8 | 40 | 3 | 2 | 48 |
| 87 | 1 | 1 | 0 | 1 | 3 | 15 | 0 | 0 | 32 |
| 88 | 3 | 3 | 2 | 1 | 9 | 45 | 3 | 2 | 54 |
| 89 | 2 | 3 | 2 | 1 | 8 | 40 | 2 | * | 39 |
| 90 | 3 | 1 | 1 | 1 | 6 | 30 | 1 | 1 | 44 |
| 91 | 4 | 3 | 2 | 1 | 10 | 50 | 3 | 2 | 59 |
| 92 | 1 | 2 | 0 | 0 | 3 | 15 | 0 | 0 | 32 |
| 93 | 3 | 1 | 2 | 1 | 7 | 35 | 1 | 1 | 37 |
| 94 | 1 | 1 | 2 | 0 | 4 | 20 | 0 | 0 | 40 |
| 95 | 2 | 2 | 2 | 1 | 7 | 35 | 0 | 0 | 35 |
| 96 | 2 | 2 | 2 | 1 | 7 | 35 | 0 | 0 | 44 |
| 97 | 3 | 2 | 3 | 0 | 8 | 40 | 5 | * | 50 |
| 98 | 2 | 4 | 3 | 1 | 10 | 50 | 6 | * | 64 |
| 99 | 5 | 4 | 1 | 0 | 10 | 50 | 3 | 2 | 63 |
| 100 | 3 | 2 | 1 | 2 | 8 | 40 | 1 | 1 | 39 |
| 101 | 4 | 4 | 3 | 2 | 13 | 65 | 7 | 3 | 67 |
| 102 | 4 | 4 | 0 | 0 | 8 | 40 | 3 | 2 | 49 |
| 103 | 3 | 2 | 0 | 1 | 6 | 30 | 1 | 1 | 32 |
| 104 | 3 | 3 | 1 | 0 | 7 | 35 | 3 | 2 | 42 |
| 105 | 4 | 4 | 3 | 0 | 11 | 55 | 7 | 3 | 64 |
| 106 | 1 | 2 | 1 | 0 | 4 | 20 | 0 | 0 | 32 |
| 107 | 1 | 1 | 1 | 1 | 4 | 20 | 0 | 0 | 35 |
| 108 | 1 | 2 | 1 | 0 | 4 | 20 | 0 | 0 | 46 |
| 109 | 1 | 2 | 1 | 2 | 6 | 30 | 0 | 0 | 42 |
| 110 | 3 | 5 | 0 | 0 | 8 | 40 | 3 | 2 | 47 |
| 111 | 2 | 2 | 1 | 1 | 6 | 30 | 0 | 0 | 53 |
| 112 | 2 | 2 | 1 | 0 | 5 | 25 | 0 | 0 | 32 |
| 113 | 3 | 2 | 3 | 0 | 8 | 40 | 5 | * | 40 |
| 114 | 4 | 3 | 2 | 1 | 10 | 50 | 3 | 2 | 67 |
| 115 | 3 | 2 | 0 | 0 | 5 | 25 | 1 | 1 | 43 |
| 116 | 4 | 2 | 0 | 0 | 6 | 30 | 1 | 1 | 49 |
| 117 | 4 | 4 | 3 | 0 | 11 | 55 | 7 | 3 | 61 |
| 118 | 4 | 4 | 0 | 0 | 8 | 40 | 3 | 2 | 49 |
| 119 | 4 | 4 | 3 | 2 | 13 | 65 | 7 | 3 | 54 |
| 120 | 2 | 3 | 2 | 1 | 8 | 40 | 2 | * | 50 |
| 121 | 1 | 2 | 1 | 0 | 4 | 20 | 0 | 0 | 35 |
| 122 | 1 | 1 | 0 | 0 | 2 | 10 | 0 | 0 | 32 |
| 123 | 4 | 4 | 3 | 2 | 13 | 65 | 7 | 3 | 75 |
| 124 | 4 | 4 | 3 | 1 | 12 | 60 | 7 | 3 | 90 |
| 125 | 2 | 1 | 2 | 1 | 6 | 30 | 0 | 0 | 36 |
| 126 | 4 | 2 | 1 | 0 | 7 | 35 | 1 | 1 | 36 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 127 | 3 | 3 | 2 | 1 | 9 | 45 | 3 | 2 | 70 |
| 128 | 1 | 2 | 0 | 1 | 4 | 20 | 0 | 0 | 37 |
| 129 | 3 | 3 | 2 | 2 | 10 | 50 | 3 | 2 | 62 |
| 130 | 3 | 2 | 1 | 0 | 6 | 30 | 1 | 1 | 32 |
| 131 | 3 | 2 | 1 | 0 | 6 | 30 | 1 | 1 | 35 |
| 132 | 4 | 3 | 2 | 1 | 10 | 50 | 3 | 2 | 69 |
| 133 | 2 | 3 | 2 | 0 | 7 | 35 | 2 | * | 39 |
| 134 | 2 | 2 | 1 | 0 | 5 | 25 | 0 | 0 | 40 |
| 135 | 3 | 2 | 3 | 0 | 8 | 40 | 5 | * | 50 |
| 136 | 4 | 3 | 2 | 1 | 10 | 50 | 3 | 2 | 60 |
| 137 | 4 | 4 | 3 | 2 | 13 | 65 | 7 | 3 | 87 |
| 138 | 4 | 2 | 1 | 1 | 8 | 40 | 1 | 1 | 50 |
| 139 | 3 | 2 | 1 | 2 | 8 | 40 | 1 | 1 | 41 |
| 140 | 5 | 3 | 3 | 1 | 12 | 60 | 7 | 3 | 84 |
| 141 | 3 | 1 | 2 | 1 | 7 | 35 | 1 | 1 | 39 |
| 142 | 2 | 1 | 0 | 0 | 3 | 15 | 0 | 0 | 32 |
| 143 | 3 | 2 | 2 | 1 | 8 | 40 | 1 | 1 | 42 |
| 144 | 4 | 1 | 3 | 0 | 8 | 40 | 5 | * | 54 |
| 145 | 1 | 2 | 1 | 0 | 4 | 20 | 0 | 0 | 34 |
| 146 | 3 | 2 | 2 | 1 | 8 | 40 | 1 | 1 | 42 |
| 147 | 3 | 2 | 0 | 1 | 6 | 30 | 1 | 1 | 45 |
| 148 | 4 | 3 | 2 | 0 | 9 | 45 | 3 | 2 | 67 |
| 149 | 4 | 4 | 2 | 3 | 13 | 65 | 11 | * | 61 |
| 150 | 3 | 3 | 1 | 1 | 8 | 40 | 3 | 2 | 69 |
| 151 | 2 | 1 | 0 | 0 | 3 | 15 | 0 | 0 | 32 |
| 152 | 3 | 0 | 1 | 0 | 4 | 20 | 1 | 1 | 35 |
| 153 | 2 | 3 | 2 | 0 | 7 | 35 | 2 | * | 38 |
| 154 | 4 | 1 | 1 | 0 | 6 | 30 | 1 | 1 | 42 |
| 155 | 3 | 3 | 2 | 0 | 8 | 40 | 3 | 2 | 35 |
| 156 | 2 | 0 | 0 | 0 | 2 | 10 | 0 | 0 | 32 |
| 157 | 3 | 1 | 1 | 0 | 5 | 25 | 1 | 1 | 35 |
| 158 | 4 | 3 | 1 | 0 | 8 | 40 | 3 | 2 | 60 |
| 159 | 1 | 1 | 3 | 1 | 6 | 30 | 4 | * | 40 |
| 160 | 3 | 2 | 1 | 0 | 6 | 30 | 1 | 1 | 52 |
| 161 | 1 | 1 | 2 | 1 | 5 | 25 | 0 | 0 | 41 |
| 162 | 1 | 0 | 2 | 0 | 3 | 15 | 0 | 0 | 32 |
| 163 | 4 | 3 | 3 | 1 | 11 | 55 | 7 | 3 | 84 |
| 164 | 4 | 4 | 3 | 1 | 12 | 60 | 7 | 3 | 91 |
| 165 | 4 | 3 | 4 | 0 | 11 | 55 | 7 | 3 | 60 |
| 166 | 3 | 2 | 2 | 2 | 9 | 45 | 1 | 1 | 48 |
| 167 | 3 | 1 | 1 | 0 | 5 | 25 | 1 | 1 | 35 |
| 168 | 4 | 3 | 1 | 0 | 8 | 40 | 3 | 2 | 38 |
| 169 | 3 | 2 | 1 | 1 | 7 | 35 | 1 | 1 | 58 |
| 170 | 4 | 3 | 2 | 0 | 9 | 45 | 3 | 2 | 62 |
| 171 | 3 | 0 | 2 | 0 | 5 | 25 | 1 | 1 | 32 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 172 | 2 | 1 | 2 | 0 | 5 | 25 | 0 | 0 | 35 |
| 173 | 5 | 3 | 2 | 1 | 11 | 55 | 3 | 2 | 61 |
| 174 | 3 | 2 | 3 | 0 | 8 | 40 | 5 | * | 32 |
| 175 | 1 | 1 | 1 | 1 | 4 | 20 | 0 | 0 | 32 |
| 176 | 2 | 1 | 1 | 1 | 5 | 25 | 0 | 0 | 39 |
| 177 | 3 | 3 | 2 | 1 | 9 | 45 | 3 | 2 | 60 |
| 178 | 5 | 4 | 3 | 1 | 13 | 65 | 7 | 3 | 88 |
| 179 | 2 | 0 | 3 | 1 | 6 | 30 | 4 | * | 52 |
| 180 | 4 | 3 | 1 | 1 | 9 | 45 | 3 | 2 | 43 |
| 181 | 2 | 2 | 2 | 1 | 7 | 35 | 0 | 0 | 43 |
| 182 | 2 | 1 | 1 | 1 | 5 | 25 | 0 | 0 | 44 |
| 183 | 3 | 1 | 3 | 1 | 8 | 40 | 5 | * | 40 |
| 184 | 2 | 2 | 1 | 0 | 5 | 25 | 0 | 0 | 39 |
| 185 | 3 | 3 | 2 | 1 | 9 | 45 | 3 | 2 | 37 |
| 186 | 4 | 3 | 2 | 0 | 9 | 45 | 3 | 2 | 55 |
| 187 | 4 | 3 | 3 | 0 | 10 | 50 | 7 | 3 | 96 |
| 188 | 2 | 3 | 1 | 0 | 6 | 30 | 2 | * | 50 |
| 189 | 1 | 1 | 3 | 1 | 6 | 30 | 4 | * | 52 |
| 190 | 3 | 2 | 0 | 1 | 6 | 30 | 1 | 1 | 39 |
| 191 | 1 | 3 | 2 | 1 | 7 | 35 | 2 | * | 40 |
| 192 | 2 | 1 | 2 | 1 | 6 | 30 | 0 | 0 | 40 |
| 193 | 3 | 2 | 2 | 1 | 8 | 40 | 1 | 1 | 58 |
| 194 | 3 | 1 | 1 | 0 | 5 | 25 | 1 | 1 | 41 |
| 195 | 2 | 1 | 3 | 1 | 7 | 35 | 4 | * | 32 |
| 196 | 4 | 1 | 0 | 0 | 5 | 25 | 1 | 1 | 37 |
| 197 | 2 | 2 | 2 | 2 | 8 | 40 | 0 | 0 | 50 |
| 198 | 2 | 1 | 2 | 2 | 7 | 35 | 0 | 0 | 35 |
| 199 | 5 | 3 | 3 | 2 | 13 | 65 | 7 | 3 | 69 |
| 200 | 3 | 3 | 2 | 1 | 9 | 45 | 3 | 2 | 55 |
| 201 | 4 | 3 | 1 | 0 | 8 | 40 | 3 | 2 | 48 |
| 202 | 2 | 1 | 2 | 0 | 5 | 25 | 0 | 0 | 44 |
| 203 | 4 | 3 | 3 | 1 | 11 | 55 | 7 | 3 | 80 |

**Note:'*'indicates 'no fit'**