EXPLORING OPERATIONALIZATION OF LEARNING STYLES OF STUDENTS IN GEOMETRY

A

THESIS

BY

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IN THE PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER'S IN MATHEMATICS OF EDUCATION

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Letter of Certificate

This is to certify that Mr. Devendra Bhandari a student of academic year 2070/071 with campus Roll Number 378 Thesis Number 1404 Exam Roll Number 280407 (2073) and TU registration number 9-2-408-179-2008 has completed this thesis for the period prescribed by the rules and regulations of Tribhuvan University, Nepal. This thesis entitled '**Exploring Operationalization of Learning Styles of Students in Geometry'** has been prepared based on the results of his investigation. I, hereby recommend and forward that his thesis be submitted for the evaluation as the partial requirements to award the degree of Master of Education.

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(Prof. Dr. Bed Raj Acharya)

Head

Date: February 14, 2021

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Letter of Approval

This thesis entitled "**Exploring Operationalization of Learning Styles of Students in Geometry**" submitted by Mr. Devendra Bhandari in partial fulfillment of the requirements for the Master's Degree in Education has been approved.

Viva-Voce Committee	**Signature**
Prof. Dr. Bed Raj Acharya (Chairman)	.....
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Recommendation for Acceptance

This is to certify that Mr. Devendra Bhandari has completed his M. Ed. thesis entitled "**Exploring Operationalization of Learning Styles of Students in Geometry**" under my supervision during the period prescribed the rules and regulations of Tribhuvan University, Kirtipur, Kathmandu, Nepal. I recommended and forward his thesis to the Department of Mathematics Education to organize final viva-voce.

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Declaration

This dissertation contains no material which has been accepted for the award of other degree in any institutions. To the best of my knowledge and belief, this thesis contains no material previously published by any authors except due acknowledgement has been made.

……

Devendra Bhandari

Date: March 4, 2021

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Dedication

To my parents

Acknowledgements

There are lots of people I must acknowledge for their support to form this research. First and foremost, I would like to express my deepest gratitude to my thesis supervisor Ms. Sarala Luitel, for her professional guidance and support from beginning to the end of this research.

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The special thanks should be given to the participants, the case of my study for their participation and, principal and teachers of mathematics of my study school.

As the final note of appreciation should be given to my parents who afford my education up to university degree and taught me how to take the step.

……..……..

Devendra Bhandari

Abstract

The title of this research was **Exploring Operationalization of Learning Styles of Students in Geometry**. The main purpose of this research was to explore operationalization of learning styles in geometry learning. In order to achieve this objective, the researcher used single case study taking a geometry class as the single case. The sample of this study was taken based on purposive sampling techniques from the Dang District of Nepal. The researcher observed the geometry class for 20 days continuously using observation protocol and then administered students learning style questionnaire comprised of 33 items. The researcher analyzed the questionnaire data using frequency by performing SPSS 21.0 setting 0.05 level of significance. The observation data were analyzed based on thematic approach and then calculated its frequency. The results of this research showed that majority of the students were logical and visual learners in geometry classroom. But only few students preferred verbal learning styles in geometry classroom. Thus, it is necessary to use logical and visual teaching styles and strategies in geometry classroom in order to improve students' learning experiences in mathematics.

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Chapter I

INTRODUCTION

Background of the Study

It is commonly believed notion that each learner has individual learning styles. However, these individually different learning styles have influence on students' achievement (Li, Han & Fu, 2018). Students change their learning styles as their grow up or they get more experience in learning a particular subject (Spoon & Schell, 1998). Student in geometry classroom come from diverse background and so they have different learning styles to gain geometry meaningfully. It means that students in geometry lesson do not have fixed learning styles. Moreover, providing students with multiple ways to learn content has been shown to improve student learning (Hattie, 2011). In other words, successful use of different learning styles in mathematics learning supports students to learn mathematics effectively. Thus, teachers of mathematics need to understand the students learning styles in order to match their teaching styles.

Learning style is a way of learning geometry through which students understand geometry making their own visual mental image. According to Dunn (1983), learning style is based on the concept that individuals differ significantly in the way (or style) that they concentrate, absorb, and retain new information. For instance, when learning how to construct a square, some students understand the process by following verbal instructions, while others have to visually manipulate the square themselves. This notion of individualized learning styles has gained widespread recognition in education theory and classroom management strategy.

It means that adaptation of various learning styles in mathematics refers to the

understanding of different learning styles have positive and competent results in overall learning process. Learning styles is useful to connect previous learning experience to new one. However, in each phase of learning students may apply different learning styles in their own capacity and state of experiences. Moreover, Dunn (1983) stated that students' emotion, structure of the contents may affect the learning styles. It means that students have different learning styles in each contents of mathematics, particularly in geometry learning.

In the context of Nepal, national achievement of students in geometry is very low (Education Review office, 2014). Moreover, this report reveals that students were able to recall the information related to geometry. However, they were not able to perform higher order thinking skills and application of geometry in required sector.

More importantly, this report did not focus on how to address students learning styles in mathematics classroom. But some research shows that there is relationship between students learning styles and their achievement (Li, Han & Fu, 2018). Similarly, Landrum and McDuffie (2010) emphasized that teachers and educators need to understand students learning styles to improve their quality of instruction. It seems clear that teachers' understanding of learning styles can influence the students learning in mathematics. Thus, it has become important for mathematics teachers to understand the differences in their students' learning styles, so that they can implement best practice strategies into their daily activities, curriculum and assessments.

Furthermore, students' styles can be changed and measured effectively in the classroom, if students understand the basic mathematics subject matters properly. However, individual learning styles depend on cognitive, emotional and

environmental factors, as well as one's prior experience. It also shows that there is connection between perception and student learning styles in geometry learning. Thus, this study focuses on exploring students learning styles and their perceptions towards geometry learning.

Statement of the Problem

Connection of students learning styles and teacher's teaching styles sorts teaching geometry in a meaningful direction. Because there is possibility of making strong bond of present and past learning experience of learners as well as teaching approach. A mix learning style is common some students to learn geometry and they make their perception based on how they perceive or understand geometry. The improvement of perception toward the positive way provides base for higher studies in mathematics. It also causes effect in achievement of mathematics at secondary school level (Ma & Xu, 2004).

It is seen that students seen difficult to understand higher level skills in mathematics particularly in geometry in the context of Nepal (Education Review Office, 2014). However, teachers of mathematics deliver required information and cues to assist students' better understanding in geometry and students feel challenge to use factual information to their application (Bist, 2017). It seems that there is a lack of connection between student learning preference and teachers teaching styles.

According to Svecova and Rumanova (2012) combination of knowledge and learning situation can also support students´ mathematical creativity. It means that students preference in the learning situation or context, prior knowledge and teaching environment affects learning approach. Moreover, connection of teaching styles and learning styles helps students to learn more advanced geometry courses. Furthermore,

every support of motivation in mathematics education is connected with creating a student´ perceptions to mathematics and geometry (Pavlovicova & Zahorska, 2015). It Means that students learning style of geometry and perceptions towards geometry are interrelated.

In this circumstance, teachers of mathematics need to use appropriate teaching styles that fit with students learning styles in geometry. However, it is not quite easy to the teachers. So that this study was intended to explore students learning styles and perceptions towards the geometry. More precisely this study was intended to examine the following research questions:

- What are the different learning styles of students in geometry?
- Which learning styles are most common among students in order to learn geometry?
- How do students operationalize the most common leaning styles?

Objectives of the Study

The specific objectives of this study were as follows:

- To explore the learning styles of students in geometry learning
- To analysis the operationalization of learning styles of students in geometry learning.

Significance of the Study

The findings of this study would be beneficial to the different mathematics related society and individuals who are interested in mathematics teaching and learning. This research may also be convenient to consider the learning styles in teaching and learning geometry by which teaching styles and learning styles could match with each other, succinctly. In this way, this study would be helpful for

mathematics teachers, schools, curriculum developers, planners, and other personnel allied to education in the following ways:

Mathematics teachers. Finding of this study could provide important due to mathematics teachers about students' learning styles in geometry that can lead valuable insight into choosing teaching styles that matches with the students learning styles. Consequently, proper combination of both teaching styles and learning styles in geometry lesson provides fruitful result in the mathematics instruction.

Schools. This study would be all important to the school providing a clear way of how different types of learners perceive geometry learning.

The Researchers. This study would help researchers to uncover the critical area related to geometry teaching classroom that many researchers were not able to explore.

Apart from these, it would be useful to educational planners to conceptualize a policy for integration of students' ideas in teaching and learning geometry.

Delimitation of the Study

Delimitations aim to narrow the scope of a study. In other words, it is a boundary of study in which the researcher completes the research using specific criteria or tools. This study had delimited with the following areas:

This study was single case study having a group students of grade IX was considered as the case of this study.

- This study focused on students learning styles in geometry learning rather than teacher's teaching styles and other contents of mathematics. In addition to this, students' perceptions towards geometry learning were assessed to examine how different students understand geometry learning.

- The observation protocol, in-depth interview and questionnaire were used as data collection tools to collect primary data.
- The sample of this study was selected based on purposive sampling method.
- Data Collection Process was completed within 45 days including the development of tools, pilot study, actual data collection process.
- Data analysis of questionnaire was based on descriptive statistics in which the researcher calculates mean, standard deviation, percentage and observation data was analysed based on thematic approach.

Definition of Key Terms

Learning styles. Learning styles are the ways of learning or preference of learning geometry; namely, visual, verbal, physical, aural and logical.

Operationalization. Operationalization refers to how students apply the different learning styles in geometry. It also refers to procedural recognition of the learning styles in the geometry.

Chapter II

REVIEW OF RELATED LITERATURE

The review of related literature encompasses systematically identifying, locating, and analyzing documents pertaining to the research topic which is going to be studied (Gay, Mills & Airasian, 2012). It means that literature review is the systematics analysis of key things of related scientific or empirical articles. It supports the researcher to find the gap between the literature and adds the significance to the study. In addition, it helps to conduct the new research in a manner by providing the general outline of the study and avoid the unnecessary duplication. This chapter encompasses the empirical review of the literature, the theoretical framework and conceptual framework.

Empirical Review

A study carried out by Landdrum and McDuffie, (2010) entitled on "Learning Styles in the Age of Differentiated Instruction" to differentiate how students learning styles in the age of differentiated instruction differ from individualized instruction.

The researchers made conclusion that insufficient evidence, however, to support learning styles as an instructionally useful concept when planning and delivering appropriately individualized and differentiated instruction.

Li, Han and Fu, (2018) conducted a study entitled on "Exploring the relationships between students' learning styles and leaning outcomes in Engineering Laboratory Education to investigate the impact of learning preferences on learning outcome in engineering labs. The researchers used Visual (V), Aural (A), Read/Write and Kinesthetic (K), (VARK) inventory model as the indicators of students learning outcomes. The result of this study shows that learning preference of students and their

outcome are related. However, their results contradict the previous study. Furthermore, it indicates that academic understanding of learning process and its success can be analysed through learning preference of students.

Zajacova, (2016) did a research on "Research on learning Styles- Getting to know students' individualities aiming to identify individual learner's learning styles. The researcher used survey design among 1006 students from 27 schools with Index of Learning Styles Questionnaire (ILS) in Czech Republic. The result of that study shows that the Czech Republican students were more active rather reflective learners. More than average students were visual than verbal, with male being more visual than female. Furthermore, Czech students are sequential than global, in some cases.

Keast, (1999) conducted a study entitled on "Learning Styles in Mathematics Classrooms" to identify factors that make hindrance in the completion of mathematics in their final year as the case of girls of year 7 and 8. This was case study design.

During the investigation it became apparent that there were marked differences in the learning styles of the students. While these were not gender specific they were gender related. As the conclusion the researcher stated that there are two learning styles (separate and connected knowing) and two associated teaching styles (separate and connected teaching).

Dunn and Dunn, (1979) conducted a study on Learning styles/teaching styles: Should they or can they be matched? They claimed that 20% to 30% of students appear to be auditory, 40% are visual, and 30% to 40% are either tactual/kinesthetic, visual tactual, or some combination of the four major senses. Based on this, they argued that when instruction is predominantly of one form (e.g., lecture, or lecture/discussion) teachers should not be surprised that "so few students achieve as

well as we believe they should" (p. 240).

Akgul (2014) did research on "the effectiveness of using learning style on nine grade student's achievement in geometry, geometry thinking and attitude towards mathematics." The main objective was to investigate the effectiveness of geometry of nine grade student's mathematics achievement in geometry. To fulfill this aim the researcher selected 34 students of grade nine with case study research design was adapted private Secondary school in Bilknt district in Turky.

Similarly, Eu & Thambi (2013) studied on "effectiveness of learning style on student's achievement in In geometry." The main objectives of the study are to find the effectiveness of learning style in school geometry on student's achievement." The researcher selected the total 50 student of secondary school were involved in this case study.

Dogan & Icel (2010) did study on "the role of learning styles in the process of learning geometry." The main objective of this study was to observe effectiveness of learning style on grade ten student's achievement for the subject of triangle. The number of 120 students involve in the case study. This results show that dynamic the learning style has positive effects on students' learning and achievements also observed that it improves students' motivation with positive impact.

From the review of these literature, it seems clear that only few research focused on learning styles of learners (Landdrum & McDuffie, 2010; Li, Han & Fu 2018). However, they did not focus on mathematics learning, particularly geometry learning. Thus, there may be still gap that the preference of mathematics learners to approach geometry in the context of Nepal. While, a number of researchers accentuated that learning styles in differentiated instruction and identifying hindrance

with girls learning approach in mathematics (Landdrum & McDuffie, 2010; Keast, 1999). Therefore, this study is focused on identifying the students' learning styles in geometry learning and their perceptions towards geometry learning in the context of Nepal.

Theoretical Framework

This study was based on the Fleming's (2011) VARK model of instructional preference, where V refers to Visual, A refers to Aural, R refers to Read/Write and K refers to Kinesthetic. Since this study is based on case study with exploring learning preference of students in geometry learning and their perception towards geometry learning, the researcher used VARK model as theoretical frame of this study.

Visual Learners: "Visual learners are those that learn best things seeing them" (Fleming, 2011). These are those learners who discover by seeing and watching. In order to enhance their level of knowledge they prefer to observe things such as snaps, films, demonstrations, painting, charts and graphics. By and large their learning comes to pass through their dominant sense 'sight'. Stash (2007) convoluted visual learners as people who favor pictographic illustration. Mayzler & McGann (2010) elucidated that the visual learner is someone who ascertains best when she or he is witnessed the objects and the brain extracts the information preeminent when the sequence of event is transported in the course of the eyes. Learners having visual aptitude are characteristically affluent with imagination and are liable to be creative and inventive (Piping 2005).

Auditory Learners. They have down pat what they hear more evidently than what they perceive and witness. They acquire knowledge through hearing the things. They jump at the ideas and concepts when hear those things. They can grasp by

listening tapes, audio discussion or lectures. Moreover, they can easily commit to memory and retain when information is presented before them in the form of melody, poem or a song. Such learners at times fell unease with boring reading because they are unable to visualize well. Aural students become skilled at something by listening (Drago & Wagner 2004). Acoustic learners thrash out on answers or by listening to recording over the assessment topics (Murphy et al. 2004). Students who gain knowledge by this mode are easily interrupted by noise (Drago & Wagner 2004).

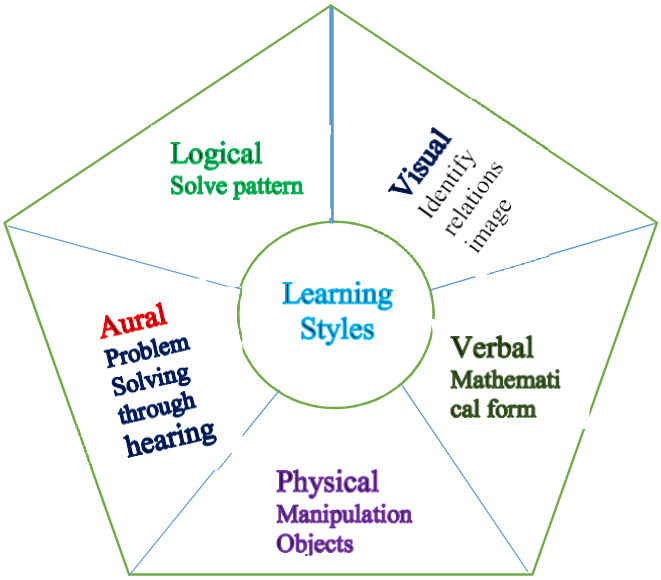
Read/write Learners. It is a style of leaning that centered round repetition of written words. Such learners learn and retain information well by having notes of the material in their mind. They preferred on the display of words and signs. Those who are able to read and write well they opt for this learning style. These students are familiar to organize lecture notes into draft form, restate classroom notes and cram multiple choice exam (MCQS) questions (Murphy et al. 2004). Besides that, according to Drago and Wagner (2004), "these students are note takers". In view of Miller (2001) this brand of apprentices can commit to memory information via piercing reading or mouthing when reading, principally when learning somewhat new.

Kinesthetic Learners. "Bodily kinesthetic have the ability to understand and solve problems in the world through body or parts of the body" (Armstrong, 2004). They learn through moving, touching and doing. Their expression is always based on bodily movement. For that intent they have exceptional balance and eye-hand collaboration. Usually such learners are active and can't sit idle for a longer period of time. Further, they express their emotions through dance and bodily movements. In this regards miming, acting, performing, crafting and composing are the exceptional tools and techniques for better and fertile learning. Consistent with Armstrong's

(2004) observation pupils that grasp this type of intelligence are affectionate to travel and are dynamic, quick in accomplishing physical skills, fond of thinking while are on move and execute well in certain athletic meadow. Wolfman & Bates (2005), on the contrary, outlined kinesthetic learning style as to increase students' learning motivation.

Conceptual Framework

A conceptual framework is the synthesis form of researcher understands about how particular study variables in the study connect with each other. It maps out the actions required in the course of the study given his previous knowledge of other researchers' point of view and his observations on the subject of research (Regoniel, 2015). The conceptual framework "sets the stage" for the presentation of the particular research question that drives the investigation being reported based on the problem statement (McGaghie, Bordage & Shea, 2001). It is the narrow form of the theoretical framework by which study variables and circumstances of the study are presented in possible diagram or pictorial form. Based on the theoretical framework discussed above, the researcher developed the following conceptual framework which makes connection with theoretical framework to present study:



Source: Fleming's VARK model, 2011.

In this conceptual framework, there are five types of learning approaches in learning in terms of students' preference.

Logical. Logical refers to mathematical reasoning techniques in which student solves pattern and identify the relationships between different shapes and objects.

Visual. Visual learning style refer to making mental image and identify its relation to other practical parts. Visual thinking is considered as visual learning.

Verbal. Verbal learning style refers to both written and spoken words.

Physical. Physical learning style refers to the manipulating objects or materials used in learning process. Students who like to learn geometry through teaching aids are considered in this category.

Aural. Aural learning refers to the learning through hearing the learning materials and students who like to learn geometry through listening are considered in this category.

Chapter III

METHODS AND PROCEDURES

This chapter presents research design, research method, and population of the study and the samples of the study with the selection mechanisms. Also, it comprises data collection tools, reliability and validity of tools, data collection procedures and finally, the data analysis and interpretation procedures. Apart from the data section, this chapter includes the ethical considerations that the researcher considered throughout the research process, as in the last section.

Research Design of the Study

The researcher used case study research, which is a qualitative research approach to conducting research on a unit of study (Gay et al, 2012) to complete this study. Case study is an empirical inquiry of exploring a contemporary phenomenon within its real-life context, especially when it is difficult to draw clear borderline between phenomenon and context (Yin, 2002). Similarly Stake (1995) avowed case study as the study of the particularity and complexity of a single case, coming to understand its activity within importance circumstances. Moreover, case study researchers should systematically attempt to assess the likely linkages between opinions, activities and interests. It helps the researcher to investigate particular empirical topic using a set of pre-specified procedures. However, in this study, the researcher particularly employed instrumental case study in which a case is examined mainly to provide insight into an issue or to revise a generalization. Although the case selected is studied in depth, the main focus is on something else (Stake, 2000: 437–8). Furthermore, the researcher used single case study. As Punch (1998) puts: The basic idea is that one case (or perhaps a small number of cases) was studied in detail, using

whatever methods seem appropriate. While there may be a variety of specific purposes and research questions, the general objective is to develop as full an understanding of that case as possible (p. 150).

The researcher used the instrumental case study because the researcher is dealing with a single case, a class of grade IX students in specific locality. Above all, the reason of working with a single case, using an analytic model which assumes that generalizability is present in the existence of any case.

Sample of the Study

This was instrumental case study having single case. The sample of the study was a group of students, who had been studying mathematics in class IX, at Ace Model school, Dang. The sample of this study was selected based on purposive sampling because the researcher prefers the 'non participant-as-observer' role in this study. Furthermore, the researcher is practicing mathematics as secondary level mathematics teacher and it was convenient to conduct the study within researcher's working area. In other words, it helps to increase the feasibility of the study as the same working school because of easy accessibility.

Tools of the Data Collection

The researcher used observation protocol and questionnaire as the data collection tool.

Observational Protocol. The researcher developed observation protocol based on AVID learning center to observe students' learning styles in the geometry classroom. This protocol contained the index of learning strategies. The researcher focused on the learning strategies used by students to learn different types of geometric concepts. The researcher's role was 'non participant-as-observer' (Gold,

1958; as cited in Babchuk, 1962), as the researcher listening, watching and taking notes. Moreover, the researcher observed the interaction in the classroom freely without influencing them. The none 'participant-as-observer' accepts the inevitable contamination of natural settings as a result of their presence; but develops relationships with informants and makes no attempt to conceal their purposes.

Learning Style Questionnaire. In this study, the researcher used Learning Style Questionnaire (LSQ) to identify the students' preference of learning in geometry learning. The LSQ questionnaire was developed by modifying the questionnaire developed by O'Brien (1985) and adapted from University of Texas Learning Center (2006). The LSQ consisted five dimensions with 33 items. The distribution of items across each dimension of LSQ is presented in the following table I:

Table 1: Distribution of Items across Each Dimension

Dimensions	**Visual**	**Aural**	**Physical**	**Logical**	**Verbal**
No of Items	8	8	8	4	5

In depth Interview. In this study, the researcher in depth interview to identify the students' preference of learning in geometry learning. For this interview, the researcher segregated the sample students into three category based on their previous achievement standard that is high, average, and low.

Reliability and Validity of Data Collection Tools

The reliability of the tools is the degree that determines data collection tools produce stable and consistent results. The validity of the tool is the degree that ensures the data collection tool measures what it claims to measure. The researcher developed a questionnaire based on five points Likert's Scale by reducing and modifying the items of the questionnaire developed by O'Brien (1985) and adapted

from University of Texas Learning Center (2006). The Learning Style Questionnaire (LSQ) consisted five sections with 35 test items. The researcher administered LSQ among the 15 students who represented the population of the study but not included in the sample of the study. Pilot testing the questionnaire provides information about instrument deficiencies as well as suggestions for improvement. Reliability of the questionnaire was determined by performing SPSS 21.0 setting 0.05 level of significance. The Cronbach's Alpha of the questionnaire was 0.88, which was good with reference to the interpretation criteria provided by George and Mellary (2003), after deleting two and revising other items. This means that the internal coefficient of the test items was strongly connected to each other. Finally, the researcher retained only 33 items in this study. The validity of the questionnaire was ensured by expert's judgement.

To ensure the reliability and validity of observation protocol and in-depth interview, the researcher used pilot testing in a small group who had similar characteristics or common features to the sample of the study. There were twelve items in in-depth interview. However, only five items were retained in this study, after ensuring validity and reliability. Some dimensions of observation protocol were deleted from original observation protocol developed by Indiana, Department of Education. The validity and reliability of the observation protocol and in-depth interview, in depth interview were confirmed by colleague review and expert's judgment.

Data Collection Procedures

The researcher had granted permission from the head of the school and then mathematics teacher to conduct the case study. For the purpose of concise communication, the researcher provided overall general information of the research

project to the principal and mathematics teacher. After granting permission from the school, the researcher started the observation of students learning ways in the geometry lessons. The observation was intended when students were engaged in interaction to each other or practicing geometric contents and problems. The researcher preferred 'non participant-as-observer' role, during observation. In this role, the researcher took appropriate movements such as walking around the classroom and little talking with the students about their work in natural setting. In other words, the researcher adopted a naturalistic approach. Although, the researcher used formal and systematic observation.

This classroom observation took 20 days, and during the observation the researcher used observation protocol. More importantly, the researcher adopted the naturalistic approach while observing the students learning styles in learning geometry. After observation, the researcher administered the questionnaire among the group of students of grade IX whose classroom interaction had been observed. Then the learning preference of students was recorded to identify the learning preference in geometry learning. After that, the questionnaire was collected and the analysis of the data was started.

Data Analysis and Interpretation Procedures

After completion of the data collection, the researcher started data analysis, the data obtained from the observation was analyzed by using thematic approach, in which the researcher generates the primary theme based on a number of secondary themes. Thematic approach of qualitative data analysis can work both to reflect reality and to unpick or unravel the surface of reality. In the initial phase of data analysis, the researcher reduced the qualitative data into different categories. More specifically, the researcher followed the qualitative data analysis procedure proposed by Bardin (1977)

(as cited in Garbin & Colleagues, 2015).

The researcher calculated frequency of each item of questionnaire based the points assigned by students using SPSS 21.0. The researcher interpreted the percentage of the majority. Finally, observation data and questionnaire data were triangulated with conceptual framework, according to their suitability.

Ethical Considerations

The ethical issues are the concerns, dilemmas and conflicts that arise over the proper way to conduct research. In this study, the researcher considered some of the ethical issues that ensure the standardisation of data collection process and conformity the reporting the study findings. The following ethical issues were considered throughout the study:

- The researcher requested for permission from the institution before planning or conducting the study.
- The researcher had a responsibility to protect particular individuals because insensitive handling of their data may harm them. This goes further than simply agreeing to negotiate the release of data, because such negotiations were always going to take place on an unequal basis.
- The researcher had an obligation to the school to protect its interests.
- Anonymity could partly fulfil this responsibility.
- The researcher made consent in recording the observation.
- The researcher did neither fabricate the data nor falsify in the reporting.
- The researcher used appropriate language that was reasonably understandable to the participants.

Chapter IV

ANALYSIS AND INTERPRETATION OF DATA

This chapter presents and discusses the results of the research. After acquiring the data from research venue using the questionnaire and observation protocol, the researcher started to analyse the data and answer the research questions. In this chapter the findings of the investigation are presented, analyzed and interpreted.

Analysis of Questionnaire Data

The researcher used LSQ to identify the students' preference of learning in geometry learning. There were 33 items across five sections of the LSQ having different options. Each dimension of LSQ is analyzed in terms of sections of LSQ.

Logical. Logical refers to mathematical reasoning techniques in which student solves pattern and identify the relationships between different shapes and objects. In other words, logical-mathematical learning style refers to students' ability to reason, solve problems, and learn using numbers, abstract visual information, and analysis of cause and effect relationships (Logsdon, 2019). There were 4 items in this section of LSQ. The students of sample were asked to respond these items and their response were recorded in terms of Often, Sometimes and Seldom. The researcher calculated the percent of each item assigned by the respondents for the purpose of the data analysis. The per cent of each item is presented in the table 2:

Table 2: Students' Logical Preference of Learning Geometry

SN	Statements	Often %	Sometimes %	Seldom %	Results
1	I try to link various concepts and then note down	81	19	0	Positive
2	I do not become easily lost, even in the solving non routine problems.	82	15	3	Positive
3	I tend to solve problems through a more trial-and-error approach, rather than from a step-by-step method.	85	4.5	10.5	Positive
4	I tend to use logical problem solving rather than answer finding.	80.5	9	11.5	Positive

The table 2 reveals that about 82 % of students used logical learning styles in geometry learning. In other words, large majority of the students were logical learners regarding geometry learning. In detail, about 85 % of students responded that they tend to solve problems through a more trial-and-error approach, rather than from a step-by-step method. Furthermore, more than four in five students were able to perform geometry problems without missing the steps or without taking misunderstanding about the ways of problems solutions. In addition to this, majority of the students used logical problem solving rather than finding facts or answer in geometry learning.

The researcher asked: *In which ways would you like to approach problem solving?* Students Replied: *We sometime make step by step techniques although it is not best way. The best way is to make connection between terms and definitions that are being used in problem solving. Sometimes we use trial and error method but it consumes more time that we haven't.*

Visual. Visual learning style refer to making mental image and identify its relation to other practical parts. Visual thinking is considered as visual learning. There were 8 items in this section of LSQ. The students of sample were asked to respond these items and their response were recorded in terms of Often, Sometimes and Seldom. The researcher calculated the percent of each item assigned by the respondents for the purpose of the data analysis. The per cent of each item is presented in the table 3:

Table 3: Students' Visual Preference of Geometry Learning

S.N.	Statements	Often %	Sometimes %	Seldom %	Results
1	I prefer to see information written on the board and supplemented by visual aids and assigned readings	40.25	25	34.75	Positive
2	I like to write things down or take notes for visual review	28.30	40.20	31.5	Negative
3	I am skillful with and enjoy developing making graphs and charts.	42	30.75	27.25	Positive
4	I can easily understand and follow directions on a map	81	12	7	Positive
5	I can understand a news article better by reading about it in the newspaper or online rather than by listening to a report about it on the radio or internet.	20	35.35	44.65	Negative
6	I think the best way to remember something is to picture it in my mind.	88	12	0	Positive
7	I am good at working and solving jigsaw puzzles and mazes.	78	12	10	Positive
8	I prefer obtaining information about an interesting subject by reading about it.	46.25	30.75	23	Positive

The table 3 reveals that majority of the students used visual preferences of learning in mathematics. In detail, about 88% of students thought that the best way to remember something is to picture it in their mind. Moreover, about 78 % of students were good at solving puzzling mazes as mathematical skills. More than four in five

students were able to understand and follow the directions on map. However, only less than half of the students were able to see information written on the board and supplemented by visual aids and assigned readings. Only one in five students were able to understand the news article related to mathematical contents published on newspaper. Nearly 25 % of students liked to take notes down for visual thinking.

The researcher asked: *How do you remember the geometric shapes*? Students Replied: *We sometime make memorize the key terms. However, it is better to use pictures or make pictorial image on mental like shape on mental phenomena.*

Verbal. Verbal learning style refers to both written and spoken words. There were 5 items in this section of LSQ. The students of sample were asked to respond these items and their response were recorded in terms of Often, Sometimes and Seldom. The researcher calculated the percent of each item assigned by the respondents for the purpose of the data analysis. The per cent of each item is presented in the table 4:

Table 4: Students' Verbal Preference of Geometry Learning

S.N.	Statements	Often %	Sometimes %	Seldom %	Results
1	I don't like to read directions; I'd rather just start doing.	32.15	38.45	29.40	Positive
2	I use self-talking while solving the problems.	45	19.45	35..55	Positive
3	Studying at a desk is not for me.	60.25	34.25	5.5	Positive
4	Before I follow directions, it helps me to see someone else do it first	82	12.35	5.65	Positive
5	I am not skilled in giving verbal explanations or directions	28.20	45	26.80	

The table 4 reveals that nearly half of the students used verbal preferences of

learning in geometry learning. In detail, about 82% of students thought that it helped them to see what to do first. Only one in five students were able to give verbal explanation. Moreover, 60 % of students were not in the preference of learning mathematics at desk through reading. More importantly, less than half of the students had the habit of self-talking while solving geometry related problems.

The researcher asked: *How do start to solve verbal problems related to geometric shapes*? Students Replied: *We sometime screen the given question and direction together and start to solve the problem. However, in most cases, we prefer to read the given direction carefully twice or thrice and then approach to solve problem. More importantly, it is great if we draw possible picture of the problems while reading the problems.*

Physical. Physical learning style refers to the manipulating objects or materials used in learning process. Students who like to learn geometry through teaching aids are considered in this category. There were 8 items in this section of LSQ. The students of sample were asked to respond these items and their response were recorded in terms of often, sometimes and seldom. The researcher calculated the percent of each item assigned by the respondents for the purpose of the data analysis. The per cent of each item is presented in the table 5:

Table 5: Students' Physical Preference of Geometry Learning

S.N.	Statements	Often %	Sometimes %	Seldom %	Results
1	I learn best when I am shown how to do something, and I have the opportunity to do it.	36.35 .	43	20.65	Positive
2	I play with coins or keys in my pocket.	20.75	75	4.25	
3	I think better when I have the freedom to move around.	6.27	85.25	8.48	
4	I find myself needing frequent breaks while studying	56	32	12	Positive
5	I prefer to use posters, models, or actual practice and other activities in class.	67.65	17.35	15	
6	I enjoy working with my hands or making things.	13.45	6	80.55	
7	I can remember best by writing things down several times.	85	12	3	Positive
8	I grip objects in my hands during learning periods	24.80	46.35	28.85	

The table 5 shows that more than half of the students used physical preference of learning. In detail, about 85 % of students thought that it could be helpful to write down things by several times. Furthermore, about 85.25 % of the students responded that they cannot learn more mathematics while they were given freedom to move around. I think better when I have the freedom to move around. It means that students were not able to learn geometry through physical learning preference on their own pace. In other words, there was no independent learning initiated with respect to physical preference of learning (Bist, 2017).

The researcher asked: *How do you approach the geometric shapes*? Students Replied: *We approach geometric shapes as making basic concepts. It would better if we realize the geometric solution in this concrete or physical form.*

Aural. Verbal learning style refers to both written and spoken words. Aural

learning refers to the learning through hearing the learning materials and students who like to learn geometry through listening are considered in this category. There were 8 items in this section of LSQ. The students of sample were asked to respond these items and their response were recorded in terms of Often, Sometimes and Seldom. The researcher calculated the percent of each item assigned by the respondents for the purpose of the data analysis. The per cent of each item is presented in the table 6:

Table 6: Students' Aural Preference of Geometry Learning

S.N.	Statements	Often %	Sometimes %	Seldom %	Results
1	I can remember best by listening to a lecture that includes information, explanations and discussions	91.15	5.70	3.15	Positive
2	I require explanations of diagrams, graphs, or visual directions.	46	38	16	Positive
3	I can tell if sounds match when presented with pairs of sounds.	29.45	37.90	32.65	
4	I do best in academic subjects by listening to lectures and tapes.	54.20	43	2.80	Positive
5	I learn to spell better by repeating words out loud than by writing the words on paper	12.45	81.30	6.25	Positive
6	I would rather listen to a good lecture or speech than read about the same material	85.12	8.90	5.98	Positive
7	I prefer listening to the news on the radio or online rather than reading about it in a newspaper or on the internet	5.30	3.30	91.40	
8	I grip objects in my hands during learning periods.	45	34.50	20.50	Positive

Table 6 shows that nearly more than three in four students responded that they were able to learn geometry through listening or explanations. In detail, about 91.15% of students could remember by listening to lecture that includes information, explanation and discussion. However, 91. 4 % of students did not prefer to learn mathematics through news on the radio or online rather than reading about it in a newspaper or on the internet. Moreover, more than four in five students were able to

learn geometry through listening.

The researcher asked: *How do you remember the definitions of geometric shapes*? Students Replied: *We sometime make memorize the key terms by listening to lectures or using other audio material but we prefer to read the definition outlined in the text book.*

Analysis of Observation of Data

For the purpose of collecting the data about how students did use different types of learning in geometry learning. The researcher developed the questionnaire based on AVID learning center. The researcher observed the geometry class for 20 days using the observation protocol given in appendix B. For the purpose of analyzing the data, the researcher used the thematic approach and then its frequency. The summary of the observation data is presented in the following table 7:

Table 7: Summary of the Observation Data

S.N.	Observed Learning Activities	Frequency	Results
1	• Students were engaged in sequential proof of geometrical theorems. • Students might need to work on seeing the big picture and systems thinking. • Students might also enjoy creating graphs, charts, timelines, and categorizing collections.	18	Logical
2	Students practiced geometrical theorems through oral drills.	4	Aural
3	Students were engaged with real world problems or ill-defined questions.	15	Verbal
4	• Students were encouraged to learn math by direct observation • Students acted out geometrical flash cards	11	Physical
	• students made graphic representations		
5	Student differentiated different shapes of geometric figures and concepts.	17	Visual

The Table 7 shows that logical learning preference was dominant in geometry

learning. This is because the researcher observed the 18 times out of 20 students preferred to logical learning styles to learn or solve geometrical problems. However, students frequently preferred the visual learning in geometry learning. In fact, visual learning was also common among the students to learn geometry. From the data analysis of questionnaire and observation, it seems clear that logical learning style was most common in geometry learning in the students of grade. However, visual learning is also prevalent in learning geometry. Aural learning style is least common in geometry learning. Students with logical learning style often seek out rules and procedures and may be less assured when those don't exist (Logsdon, 2019). It means that students may not be tolerant when others don't follow logical sequences, rules, or procedures. They may need to work on seeing the big picture and systems thinking. Furthermore, they enjoy to work with physical instruments like computers and other hand held teaching materials. This was also common among the visual learners that seek to identify the relationships among different shapes and concepts (Logsdon, 2019).

Chapter V

SUMMARY, FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the summary and findings of the study, conclusion and implication of the study based on the analysis and interpretation of data in previous Chapter IV. Then finally the recommendation for future research areas are presented.

Summary

This was the single case study which had been completed within a month in a geometry classroom. The primary purpose of the study was to explore the learning styles in geometry learning. In addition, this study intended to analysis the operationalization of learning styles of students in geometry learning. The researcher used case study with purposive sampling techniques to complete the study. The researcher took a geometry class of 34 students from Ace secondary school, Dang as the case of the study.

In the initial phase of the study, the researcher observed a class of geometry for 20 days using observation protocol. The researcher preferred 'non participant-as-observer' role, during observation. In this role, the researcher took appropriate movements such as walking around the classroom and little talking with the students about their work in natural setting. In other words, the researcher adopted a naturalistic approach. Although, the researcher used formal and systematic observation. After observation, the researcher administered the questionnaire consisted 33 items across five dimensions of LSQ among the group of students of grade IX whose classroom interaction had been observed. Then the learning preference of students was recorded to identify the learning preference in geometry learning.

After completion of the data collection, the researcher started data analysis, the data obtained from the observation was analysed by using thematic approach, in which the researcher generates the primary theme based on a number of secondary themes. Thematic approach of qualitative data analysis can work both to reflect reality and to unpick or unravel the surface of reality. The researcher calculated frequency of each item of questionnaire based the points assigned by students using SPSS 21.0.

The researcher interpreted the percentage of the majority. Finally, observation data and questionnaire data were triangulated with conceptual framework, according to their suitability.

Based on the analysis and interpretation of the data, there was enough evidence that mathematics teachers had positive perception toward the active learning in the mathematics classroom. However, the implementation of active learning was poor.

Findings

The following were the main finding of the study:

- Majority of the students were logical and visual in the geometry classroom.
- There were five common learning styles in geometry classroom, namely, logical, verbal, aural, visual and physical. However, logical and visual were most common learning styles in geometry.
- 85 % of students tended to solve problems through a more trial-and-error approach, rather than from a step-by-step method. Furthermore, more than four in five students were able to perform geometry problems without missing the steps or without taking misunderstanding about the ways of problems solutions.

- 88% of students thought that the best way to remember something is to picture it in their mind. Furthermore, more than four in five students were able to understand and follow the directions on map.
- Nearly 92 % of students could remember by listening to lecture that includes information, explanation and discussion. However, the figure for the students who did not prefer to learn mathematics through news on the radio or online rather than reading about it in a newspaper or on the internet was same.
- Roughly 25 % of students preferred verbal learning in geometry learning.

Conclusion

Students learning preference in geometry learning plays a vital role in promoting the students' achievement. It ensures the activities to be carried out by the learners. Apart from this, learning styles help teachers to change their teaching styles in order to promote effective learning in mathematics. The successful exploitation of students' learning preferences in geometry learning shares the full range of tasks to be designed to the students to engage them time to time in the learning activities.

Moreover, the knowledge of students learning styles in geometry learning helps the teachers of mathematics to control the unnecessary behaviours of the students. Then teachers can encourage the activities related to creativity, independent learning, visual thinking, application of mathematics to real-world problems, and searching the meaning of knowledge. Thus, learning styles of students helps teachers to improve students' higher order thinking skills and diverse concerning the real problems.

Thus, it is affirmed that most of the students preferred logical learning styles in geometry learning. However, their real practices of logical learning style are mixed

with visual learning in Nepal. The preference of learning generates the quality education and students' success in the mathematics because it develops necessary skills. Thus, it is necessary to use logical and visual related teaching techniques and strategies in order to improve mathematics instruction, quality of education and Provide an ample opportunity to the students to learning mathematics, especially geometry in Nepal.

Implication of the Research

The results of this study may lead valuable insight into the improving the national achievement of the students in mathematics and giving the worth in applying the best learning preferences for mathematics in the classroom. The result of this study has a wide range of application from curriculum designer to the actual practiser of mathematics. Based on the findings and conclusion of the study, the following are the significant implication:

- It is recommended that the ministry of education should encourage teachers of mathematics to understand the importance of learning styles in geometry learning.
- It is recommended that teachers of mathematics should use effective and sensitive teaching style that would utilize the students learning styles.
- It is recommended that teachers of mathematics should be encouraged to use flexible and wide-ranging of instructional planning through training packages.
- It is recommended that teachers need to use diversity of teaching aids to exploit students learning styles in geometry learning.

Recommendations for Future Research

This study has focused on the exploring students' learning styles in geometry

learning based on case study design including a class of geometry from grade IX students in Dang District. The other researcher may carry out the study based on the considerable sample and the other context or settings to explore different learning styles of students regarding geometry learning. For future research related to this topic, it is recommended that the researchers use a survey in order to acquire more reliable, informative and better results. This is because present study was restricted to case study of the geometry class comprising 34 students. Based on the experience of this study the researcher has made the following recommendations for the further study:

- It is recommended that researchers should also take the consideration on other variables such as lower form students, their previous test result, proficiency level as well as their age that may influence their choice of learning styles. By ascertaining all the above factors, the researchers along with many academicians can use the information to accommodate effectively to the different learning styles of their learners.
- It is recommended that the researchers could compare teaching styles and learning styles in geometry learning in order to identify their effectiveness.
- It is recommended that further research may be carried out in order to identify teachers' opinions regarding students learning styles and how they prioritize these preferences in mathematics instructions.
- It is recommended that further researchers could identify the learning platform in which teachers use students' learning styles to optimize the learning in geometry learning.

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Appendix A

Survey Questionnaire

Dear Participants,

My name is Devendra Bhandari and I am a graduate student at University Campus, TU, Kirtipur. I am enrolled in the Mathematics Education program and am beginning the research for my Master's Thesis. I'm currently working on teaching profession as well as the study—looking at exploring operationalization of learning styles of students in geometry in mathematics classroom. You are invited to participate in this research project about your exploring operationalization. Your participation will involve completing a questionnaire.

Students' Logical Preference of Learning Geometry					
SN	**Statements**	**Often %**	**Sometimes %**	**Seldom %**	**Results**
1.	I try to link various concepts and then note down				
2.	I do not become easily lost, even in the solving non routine problems.				
3.	I tend to solve problems through a more trial-and-error approach, rather than from a step-by-step method.				
4.	I tend to use logical problem solving rather than answer finding.				

Students' Visual Preference of Geometry Learning					
5.	I prefer to see information written on the board and supplemented by visual aids and assigned readings				
6.	I like to write things down or take notes for visual review				
7.	I am skillful with and enjoy developing making graphs and charts.				
8.	I can easily understand and follow directions on a map				
9.	I can understand a news article better by reading about it in the newspaper or online rather than by listening to a report about it on the radio or internet.				
10.	I think the best way to remember something is to picture it in my mind.				
11.	I am good at working and solving jigsaw puzzles and mazes.				
12.	I prefer obtaining information about an interesting subject by reading about it.				
Students' Verbal Preference of Geometry Learning					
13.	I don't like to read directions; I'd rather just start doing.				
14.	I use self-talking while solving the problems.				

15.	Studying at a desk is not for me.				
16.	Before I follow directions, it helps me to see someone else do it first				
17.	I am not skilled in giving verbal explanations or directions				
Students' Physical Preference of Geometry Learning					
18.	I learn best when I am shown how to do something, and I have the opportunity to do it.				
19.	I play with coins or keys in my pocket.				
20.	I think better when I have the freedom to move around.				
21.	I find myself needing frequent breaks while studying				
22.	I prefer to use posters, models, or actual practice and other activities in class.				
23.	I enjoy working with my hands or making things.				
24.	I can remember best by writing things down several times.				
25.	I grip objects in my hands during learning periods				
Students' Aural Preference of Geometry Learning					
26.	I can remember best by listening to a lecture that includes information,				

	explanations and discussions				
27.	I require explanations of diagrams, graphs, or visual directions.				
28.	I can tell if sounds match when presented with pairs of sounds.				
29.	I do best in academic subjects by listening to lectures and tapes.				
30.	I learn to spell better by repeating words out loud than by writing the words on paper				
31.	I would rather listen to a good lecture or speech than read about the same material				
32.	I prefer listening to the news on the radio or online rather than reading about it in a newspaper or on the internet				
33.	I grip objects in my hands during learning periods.				

Appendix B

Indepth Interview Questionnaire

1. In which ways would you like to approach problem solving?
2. How do you remember the geometric shapes?
3. How do you start to solve verbal problems related to geometric shapes?
4. How do you approach the geometric shapes?
5. How do you remember the definition of geometric shapes?